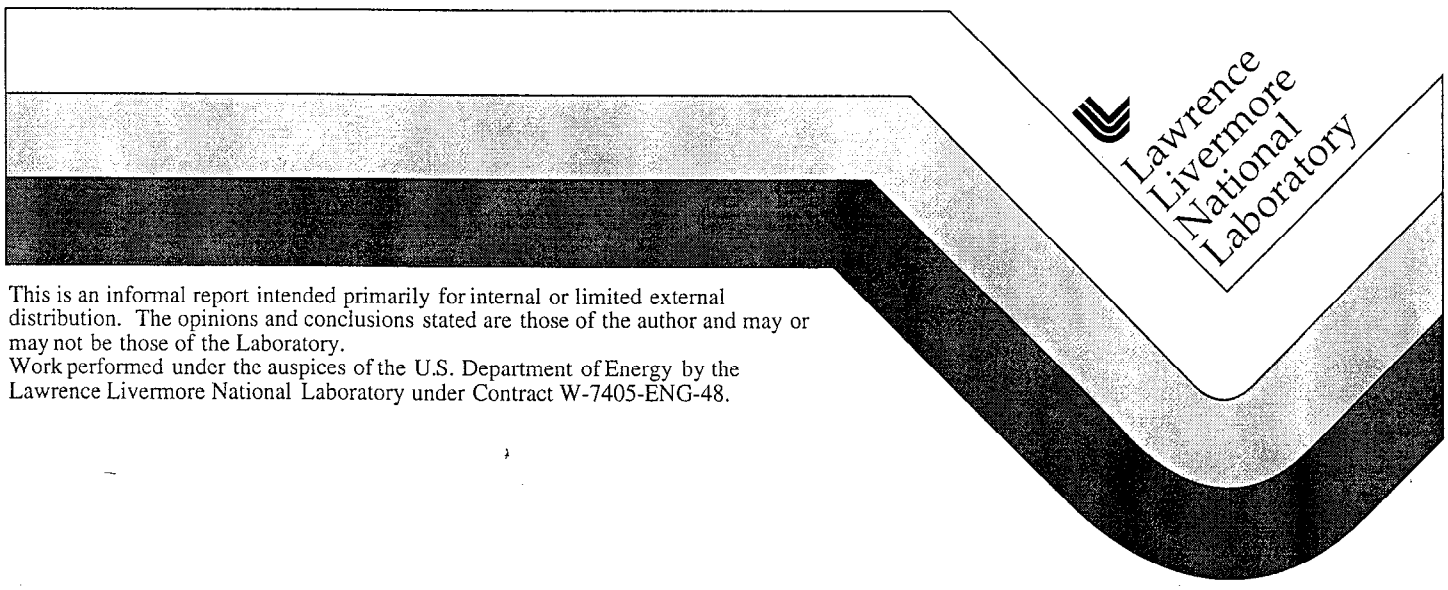
UCRL-ID-133534

FY98 Final Report for the Expedited Technology Demonstration Project: Demonstration Test Results for the Integrated MSO Waste Treatment System

Peter C. Hsu
Martyn G. Adamson
David L. Hipple
Robert W. Hopper

November 1998



FY98 Final Report for the Expedited Technology Demonstration Project: Demonstration Test Results for the Integrated MSO Waste Treatment System

Peter C. Hsu, Martyn G. Adamson, David L. Hipple, and
Robert W. Hopper

Lawrence Livermore National Laboratory
Expedited Technology Demonstration Project
Earth & Environmental Science Directorate
Livermore, CA 94550

Prepared for: U. S. Department of Energy
Oakland Operations Office
Waste Management Division

November 1998

Contents

TABLES....3
FIGURES....4
EXECUTIVE SUMMARY....5
1. Introduction....8
2. Background....8
3. Process Description....9
4. System Description....10
5. Design of Experiments in the MSO/OFF-Gas System....21
6. Salt Recycle Experiments....23
7. Final Forms Experiments....25
8. Demonstration Results for the MSO/Off-Gas System....28
9. Results of the Demonstration of the Salt Recycle System....51
10. Results of the Ceramic Final Forms Demonstration....55
11. Lessons Learned....55
12. Cost Analysis....58
13. Conclusions....58
REFERENCES....59
APPENDIX 1

Tables

Table 1 Run Conditions

Table 2 Effect of Temperature on the Ethylene Glycol Run

Table 3 Effect of % Excess Air for the Ethylene Glycol Run

Table 4 Effect of % Excess Air for the Toluene Run

Table 5 MSO Processor Data Sheet for Toluene Run

Table 6 Run Conditions for Heteroatom-containing Organic Liquids

Table 7 Off-gas Composition for Feed of Tolune/Pyridine

Table 8 Conversion of Organic Nitrogen into NO_x in the Molten Salt

Table 9 Off-gas Composition for the MSO Runs with Halides, Sulfur, and Phosphorous-Containing Feeds

Table 10 Run Conditions

Table 11 Off-gas Composition for the Solid Feeds

Table 12 Run Conditions for Test Series IV

Table 13 Off-gas Composition for the Radioactive-spiked Organic Liquids

Table 14 C-14 Level in the C-14 Labeled Toluene Run

Table 15 Off-gas Analyzer Readings

Table 16 Destruction and Removal Efficiency for the MSO Demonstration with Uranium And 2,4-Dichlorophenol-spiked Organics

Table 17 Real Test Specimens for MSO Treatability Study in FY98

Table 18 Test Methods and Locations for the Treatability Study

Table 19 Off-gas Composition for RTS#1 and RTS#2

Table 20 Feed Rates, Emission Rates, and DREs for RTS#1

Table 21 Results for Dioxin and Furan Emissions for RTS#1

Table 22 Feed Rates, Emission Rates, and DREs for RTS#2

Table 23 Results for Dioxins and Furan Emissions

Table 24 Cation Compositions of SR1, SR2, SR3 Before and After Salt Recyle

Table 25 Cation Compositions of SR5 and SR6 Before and After Salt Recyle

Table 26 Cation Compositions in SR4 Salt Before and After Salt Recycle

Table 27 Unit Costs for Various Radioactive Feeds Based on 3-Vessel System (in $/kg)

Figures

Fig. 1 Integrated MSO System

Fig. 2 MSO Reaction Vessel

Fig. 3 Off-gas System

Fig. 4 Salt Recycle System Flow Diagram

Fig. 5 Ceramic Waste Form Process Functional Flow Diagram

Fig. 6 Floor Plan (Final Forms)

Fig. 7 Flowsheet for Aqueous Processing of Spent Salt

Fig. 8 Salt Plug in the Drain Pipe

Fig. 9 Toluene Feed at 1.2 kg/hr, 30% excess air, salt at 950 C 98 hrs run)

Fig. 10 3 kg/hr Ion Exchange Resin (Amberlite), salt at 950 C

Fig. 11 C-14 Activity in Salt & Off-gas

Fig. 12 MSO Flow Balance for Feed Stream in LLW-008 (Chlorinated Solvents)

Fig. 13 MSO Flow Balance for Feed Stream LLW-009 (PCB Waste Oils)

EXECUTIVE SUMMARY

Molten Salt Oxidation (MSO) is a robust thermal treatment process that can be used to oxidatively and efficiently destroy the organic constituents of mixed and hazardous wastes. In the Expedited Technology Demonstration Project, an integrated pilot-scale MSO demonstration facility has been installed and operated at Lawrence Livermore National Laboratory (LLNL). This facility, which has been operational since December 1997, was built to demonstrate the capability of processing organic feed at a commercially useful scale (5 to 7 kg per hour). The integrated MSO treatment train consists of several subsystems: a primary MSO processor (reaction vessel), an off-gas conditioning system, a salt recycle system, and a ceramic final forms immobilization system. The MSO/off-gas system began operations in December 1997, while the salt recycle system and the ceramic final forms immobilization system were activated in May 1998 and September 1998, respectively. During FY98, we have successfully conducted tests in the MSO facility on a variety of liquid and solid organic feeds: chlorinated solvents, tributyl phosphate/kerosene mixtures, PCB-contaminated waste oils and solvents, shredded booties and coveralls, plastic pellets, ion-exchange resins, activated carbon, several radioactive-spike organics, and two well-characterized low-level liquid mixed wastes. For the last two feeds, which were samples of real LLNL mixed wastes, the tests were conducted under the California EPA protocol for Treatability Tests.

After initial activation of the MSO/off-gas system (which included demonstration of the effectiveness of the frozen salt plug, and the ability to quickly load and drain salt from the MSO vessel), tests on a variety of simulated and real organic wastes were conducted in five distinct test series (I-V). In Series I, three common organic liquids with a range of viscosities were treated to verify the function of each component in the MSO/off-gas system and to establish/verify the optimum conditions for organic destruction. Toluene, ethylene glycol and oil-toluene mixtures were fed for 1- to 8-hr periods at rates of 1.2 to 2.6 kg/hr with 10–60% excess air at process temperatures ranging from 900 to 950°C. The best DREs (>99.9999%) and lowest NO_x levels (8-115 ppm) were obtained at 925-950°C with 30% excess air; the feed rates and optimal air flow corresponded to superficial velocities of 1 ft/sec through the reactor. Long-term process stability was demonstrated in an 8-hr run with toluene. In Series II, several organic liquid mixtures containing N-, P-, F-, Cl- or S-containing compounds were processed at 950°C with 30% excess air and feed rates in the range 1.18-2.23 kg/hr. Again, good DREs were obtained (>99.999%) but, as expected for the N-containing compounds, the NO_x levels immediately after the reactor were high, in some cases exceeding 1000ppm. These high NO_x levels were reduced by 94% before off-gas release by use of a catalytic converter. For compounds containing heteroatoms other than N, the heteroatom was retained quantitatively in the carbonate salt bed. In Series III, some surrogate solid waste materials were fed to the MSO reactor using a vibratory feeder and compressed air flowing through an eductor. At a reactor temperature of 950°C, and with feed rates ranging from 1.45 to 3.0 kg/hr using 30 to 65% excess air, mixed results were obtained, the degree of destruction usually depending on the feed particle dimensions. The best results were obtained with feeds having the smallest particle size, in this case an Amberlite ion-exchange resin. In Series IV, several surrogate organic liquid waste formulations spiked with radionuclides and/or dioxin precursors such as 2,4-dichlorophenol were processed at 900-950°C with 30% excess air and feed rates of 1.2 to 8.2 kg/hr. Two runs conducted with C-14 labeled toluene as feed showed that the molten carbonate bath acts as an effective sink for C-14 in the feed, and that CO_2 in the off-gas rapidly equilibrates with carbonate in the salt. Three runs conducted with highly chlorinated feeds helped establish the optimal conditions for treating two real LLNL chlorosolvent waste streams, and also confirmed that, at high chloride loadings in the salt, low total hydrocarbon (THC) levels in the off-gas (< 1ppm) – which correspond to high DREs – can accompany high CO levels in the post-reactor off-gas. A surrogate waste stream consisting of carbon tetrachloride, 1,1,1-trichloroethane, ethanol, ethylene glycol, 2,4-dichlorophenol and uranyl nitrate (1wt%), was fed with 30% excess air to the MSO processor at 2.2 and 3.3 kg/hr and superficial velocities of 1 ft/s and 1.5 ft/s, respectively, at 950°C. Using continuous off-gas monitors and separate gas sample analyses, it was shown that the system reached steady-state in 30 minutes and the off-gas

quality leaving the MSO vessel was very good under both flow conditions (<10ppm CO, <110ppm NO_x). DREs of all the principal organic hazardous constituents (POHCs), including 2,4-dichlorophenol, were better than five nines, and dioxins and furans were not detectable.

Series V comprised a treatability study of two real waste specimens from the LLNL mixed waste inventory. The first specimen (LL-W008) was chlorosolvents consisting mainly of 1,1,1-trichloroethane with low levels of radionuclides (U, tritium) and trace metals. The second specimen (LL-W009) was hydraulic oil contaminated with PCB (1567 ppm), traces of solvents and metals, and low levels of uranium and tritium. In separate runs using fresh batches of sodium carbonate, five gallons of each waste specimen was processed through the reactor at 950°C with 30% excess air at feed rates of 1.1 kg/hr (LL-W009) to 2.3 kg/hr (LL-W008). To decrease its viscosity, and hence improve the ease of delivery of LL-W009, toluene was added as a diluent. The off-gas composition was monitored continuously by on-line monitors during the runs, and comprehensive gas sampling was performed by Best Environmental, Inc., using certified EPA methods. Gas sampling was conducted from sampling ports located at the inlet and outlet of the GSS filter and from the vent of the catalytic converter. For LL-W008, the concentrations of CO and THC in the off-gas were 15.6 ppm and 0.2 ppm, respectively, considerably lower than the current standards for mixed-waste incinerators. The DREs for the six POHCs were all greater than 99.999%, with the principal constituents, MCM and toluene, exceeding six nines. The particulate loading of the off-gas immediately downstream of the GSS was $6x10^{-5}$ g/ft^3, and the HCl level was <0.0016 g/hr. Total emission of semi-volatile organics was less than 91.376 µg/min and total emission of volatile organics was less than 31.568 µg/min. The total dioxin and furan emissions from the GSS filter inlet and the catalytic converter outlet were 18.534 pg/m^3 TEQ and 17.093 pg/m^3 TEQ, respectively. All these values fall within proposed EPA regulatory limits. For the PCB-containing waste specimen LL-W009, the off-gas quality was very good, with NO_x<50ppm, CO<20ppm, and non-detectable levels of THC. With the marginal exceptions of 1,1-dichloroethene and trichlorotrifluoroethane, the DREs for the POHCs all exceeded five nines. The particulate loading of the off-gas was $1.86x10^{-6}$ g/ft^3, and the HCl level was <0.0015 g/hr. Total emission of semivolatile organics was less than 95.854 µg/min and total emission of volatile organics was less than 17.82 µg/min. The total dioxan and furan emissions from the GSS filter inlet and the catalytic converter outlet were 38.743 pg/m^3 TEQ and 9.338 pg/m^3 TEQ, respectively. These values are again below the EPA regulatory limits.

The salt recycle system was used successfully to treat six batches of spent salt generated from the MSO processor during FY98. For spent salts with high carbonate contents, it removed ash, metals, and radionuclides from the salts to levels of 20 ppm (Cr) to 500 ppm (U) and returned 95% of the salt for reuse. For spent salts with low carbonate content, salt recycle removed ash, metals, and radionuclides to levels of 0.1 ppm (U) to 1 ppm (Cr) and generated clean sodium chloride brine solutions which are not considered hazardous. For ceramic final forms, FY98 activity was largely devoted to the design and installation of the fabrication facility, and to initial testing of the major equipment items. Although the components of the system were standard commercial equipment, many modifications were needed to ensure safe and efficient operation with toxic and radioactive materials. An OSP was prepared, and initial shake-down operations were carried out. Evolutionary system modifications were in progress at the end of the fiscal year, and two new R&D issues are being addressed. Integrated operation of the Final Forms system is scheduled to begin in the first quarter of FY99. Mass balances were also calculated for each of the treatability study demonstrations, assuming integrated steady-state operation of the MSO/off-gas system, the salt recycle system, and the ceramic final forms system.

On the basis of the FY98 demonstrations, we have established that MSO is a mature, versatile and effective technology for the treatment of the following classes of organic-based hazardous and mixed wastes: halogenated solvents and refrigerants, PCB-contaminated oils and solvents, solutions of actinide complexants in nonhalogenated solvents, ion-exchange resins, granulated activated carbon, and uranium-contaminated organics. Thus, as a viable alternative to incineration,

MSO could provide a solution to many vexing waste disposal problems that continue to exist around the DOE complex. This report presents the results from operation of the MSO/off-gas system and the salt recycle system with a variety of simulated and real organic-based mixed wastes, and it also discusses general processing capabilities and our accumulated operational experience with a pilot-scale MSO system. Due to the delay in final commissioning of the ceramic final forms subsystem, evaluation of the ceramic pellets derived from the FY98 tests performed on real wastes and spiked surrogates will be reported in FY99, as will the results from follow-on MSO tests that are being conducted in FY99.

1. INTRODUCTION

MSO is a promising alternative to incineration for the treatment of a variety of organic wastes. Lawrence Livermore National Laboratory (LLNL) has prepared a facility in which an integrated pilot-scale MSO treatment system is being tested and demonstrated. The system consists of a MSO vessel with a dedicated off-gas treatment system, a salt recycle system, feed preparation equipment, and a ceramic final waste forms immobilization system. This integrated system was designed and engineered based on operational experience with an engineering-scale reactor unit and extensive laboratory development on salt recycle and final forms preparation.

The MSO/off-gas system has been operational since December 1997. The salt recycle system and the ceramic final forms immobilization became operational in May and August, 1998, respectively. We have tested the MSO facility with various organic feeds, including chlorinated solvents, tributyl phosphate/kerosene, PCB-contaminated waste oils & solvents, booties, plastic pellets, ion exchange resins, activated carbon, radioactive-spiked organics, and well-characterized low-level liquid mixed wastes. MSO is shown to be a versatile technology for hazardous waste treatment and may be a solution to many waste disposal problems in DOE sites. This report presents the results obtained from operation of the integrated pilot-scale MSO treatment system through September 1998, and therefore represents a final report for fiscal year 1998 activities.

2. BACKGROUND

In response to public concern about the application of incineration as the best demonstrated available technology (BDAT) for the treatment of organic-based mixed wastes, the Mixed Waste Management Facility (MWMF) project was initiated at LLNL in 1992. The focus of this project was to demonstrate integrated, alternative-to-incineration (non-flame) technologies for the treatment of typical low-level mixed wastes (from LLNL's inventory) at the pilot-scale. Selected alternative-to-incineration technologies, including MSO, were to be evaluated against the federal and state treatment standards that identify incineration as BDAT, thus establishing equivalency with the BDAT. The technologies were to be demonstrated in a dedicated facility (test-bed) in integrated treatment trains incorporating state-of-the-art waste characterization and feed preparation technologies, off-gas treatment, waste water treatment, and the preparation of robust ceramic final forms.

In June 1996, written direction was received from DOE-EM to descope the MWMF project and use the remaining uncosted funds to complete a limited demonstration of MSO as an integrated mixed-waste treatment process in Building 292 (B292), an existing building at LLNL. Cost estimates were developed to meet the DOE funding guidance, then incorporated into a new baseline plan titled "Expedited Technology Demonstration Project (ETDP) Baseline Revision 3.0 and FY97 Plan" which was released in October 1996. An updated version of this document was prepared based on the present test plan, and this details the system deployment/demonstration phase of the project in FY98. During FY97 and early FY98, B292 was modified using GPP funds to meet the ETDP requirements. In addition to the MSO primary unit, off-gas, and salt recycle subsystems, which are somewhat smaller than the MWMF reference design, the FY98 demonstrations include the production of ceramic final forms from process mineral residues and a limited capability for feed preparation.

Testing was originally planned to begin in October 1997 with organic compounds of interest, then it would proceed to surrogate feed streams of interest, and finally selected low-level mixed wastes supplied by LLNL's Hazardous Waste Management (HWM). The latter tests will be performed as treatability studies under the purview of California EPA's Department of Toxic Substances Control. In the DOE letter of June 1996, we were also directed to explore the application of MSO to hazardous organic wastes including those generated in weapons dismantlement, and to facilitate the transition of the MSO technology to a commercial entity. Because of a 3-month delay in the

B292 GPP start date, testing did not actually begin until December 1997. Details of the planned ETD demonstrations for FY98 can be found in Ref. 1.

Waste treatment systems are tested in order to evaluate them relative to the Federal, State and local treatment standards, residual product requirements, and effluent requirements. Ideally, the MSO demonstration waste treatment system under evaluation will be shown to meet all RCRA Land Disposal Restriction (LDR) standards including the Universal Treatment Standards (UTS) for the chosen mixed waste streams. If successful, the treatment evaluation may result in the technology being designated by the EPA as a BDAT (or result in a Determination of Equivalent Treatment to the BDAT) for a specified mixed waste stream. A successful demonstration will result in a clear determination as to whether the MSO treatment process train meets the LDR requirements for the specific waste stream.

3. PROCESS DESCRIPTION

MSO is a robust thermal treatment process for destroying organic waste. In this process, organic-containing wastes are injected with a stoichiometric excess of oxidant air under a pool of molten carbonate salts at temperatures between 700–950°C. Flameless oxidation takes place within the salt bath converting the organic components of the waste into CO_2, N_2, and water. The product off-gas leaving the processor is treated to remove any entrained salt particulate and essentially all water vapor before being discharged to the facility off-gas system. Halogens and heteroatoms such as sulfur are converted into acid gases, which are then "scrubbed" and trapped in the salt in forms such as NaCl and Na_2SO_4. Using sodium carbonate in the processor, this process occurs according to the reaction shown in Equations 1, 2, 3, and 4, where X represents generic halogens.

$$2C_aH_b + (2a+b/2)O_2 \text{ ----> } 2aCO_2 + bH_2O \quad (1)$$

For nitrogen-bearing organic wastes,

$$C_aH_bN_c + (a+b/4)O_2 \text{ ----> } CO_2 + H_2O + N_2 + NO_x \quad (2)$$

For halogenated organic wastes,

$$C_aH_bX_c + c/2Na_2CO_3 + (a+(b-c)/4)O_2 \text{ ----> } (a+c/2)CO_2 + b/2H_2O + cNaX \quad (3)$$

For sulfur-containing organic wastes,

$$C_aH_bS_c + cNa_2CO_3 + (a+b/4+3c/2)O_2 \text{ ----> } (a+c)CO_2 + b/2H_2O + cNa_2SO_4 \quad (4)$$

Other non-oxidizable inorganic constituents, heavy metals, and radionuclides are held captive in the salt, either as metals or oxides, and are easily separated for disposal.

MSO has several unique characteristics. The large thermal mass of the molten salt provides a stable heat-transfer medium that resists thermal surges and ensures temperature uniformity and is therefore able to tolerate rapid process fluctuations. Flame-outs are completely avoided, since MSO is a non-flame process that proceeds by catalytic liquid-phase oxidation reactions. Operation of the MSO system is at temperatures hundreds of degrees lower than flame combustion temperatures, which, among other things, minimizes emissions of the radioactive materials from mixed wastes. Acid gases are "scrubbed" by the alkali salts, eliminating the need for a wet off-gas scrubbing system.

4. SYSTEM DESCRIPTION

The integrated MSO system, shown in Fig. 1, consists of several subsystems. It includes a reaction vessel, an off-gas treatment system, a salt recycle system, feed preparation equipment , as well as ceramic final waste forms immobilization system. The feed preparation area includes waste receiving drums, centrifuge for solid liquid separation, a shredder for size-reducing solid wastes such gloves, booties etc. The waste is fed to the reaction vessel along with oxidant air using a top-feed injection system designed for solid and liquid waste streams at throughputs up to 7 kg/hr for chlorinated solvents. Product off-gas exiting the vessel is then treated in the off-gas system to remove entrained salt particulates, water vapor, and traces of gas species such as CO and NO_x, As waste is injected into the MSO vessel, residues of inorganic components build up in the salt bed which necessitates periodic removal of salt and replenishment with fresh salt to maintain process efficiency. Because many of the metals and/or radionuclides captured in the salt are hazardous and/or radioactive, without further treatment the removed spent salt would create a large secondary waste stream. A salt recycle system is needed to segregate these materials to minimize the amount of secondary waste, and to reduce the consumption of fresh salt. The segregated inorganic residues are then immobilized as a ceramic final form for disposal. Each subsystem is described below.

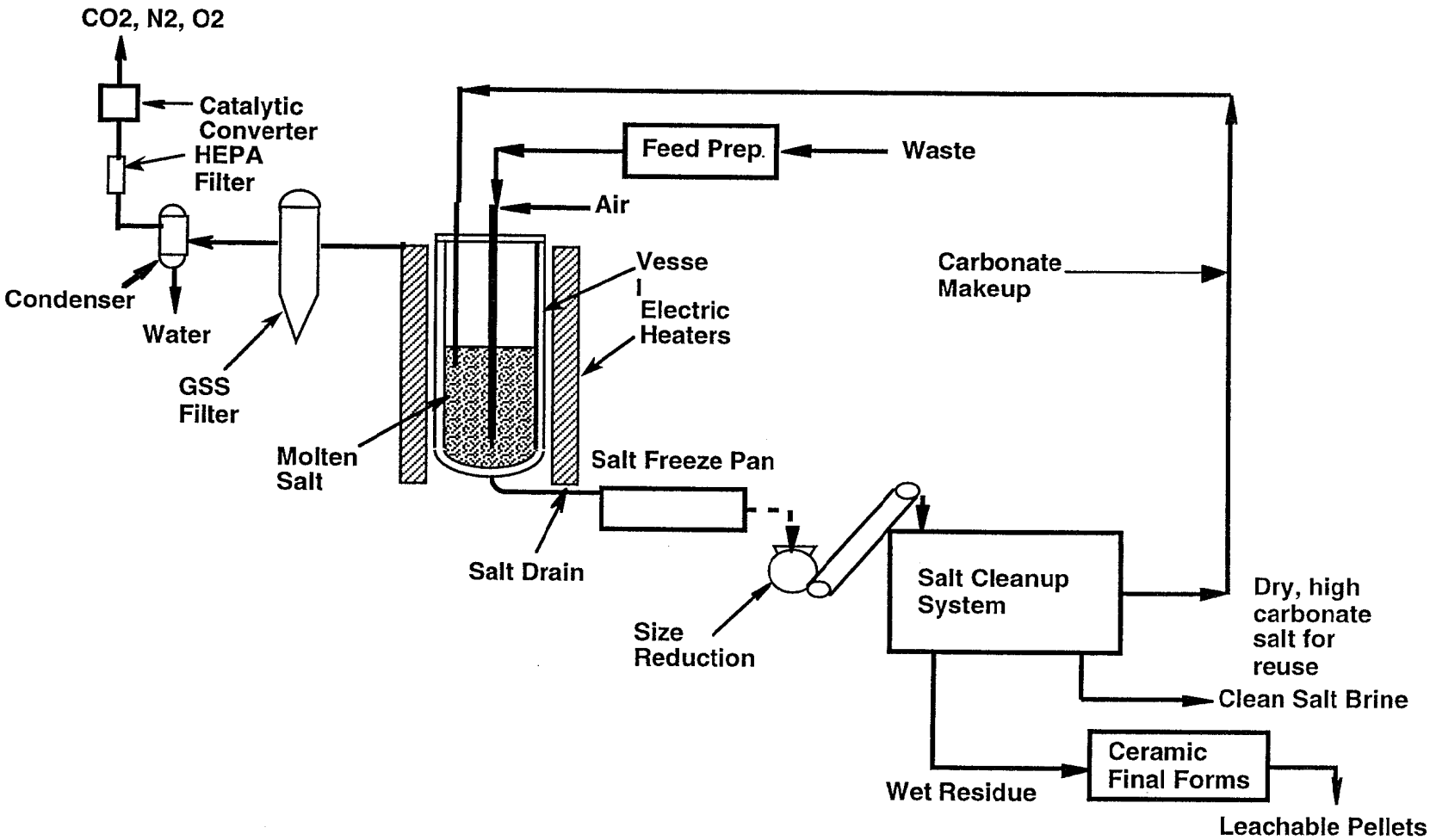
4.1. Reaction Vessel

The MSO reaction occurs in a 2.74 meter tall processor vessel, shown in Fig 2. The processor is 38.1 cm inside diameter over the top half and 29.8 cm inside diameter over the bottom half, with a 30.5 cm long, tapered transition zone in between. The normal salt load is 160 kg and fills the vessel to the bottom of the transition zone when quiet. When air and feed injection is occurring, the salt level froths up to the top of the transition zone. The freeboard area of the vessel above the salt level provides a dis-engagement zone for salt spray to separate from the off gas before it exits. There are baffles in this region to assist in separating the salt spray. The air and feed material enter through an injector lance extending through the vessel cover to the bottom of the vessel. The injector is insulated and air cooled to keep the feed temperature low until it leaves the injector and contacts the molten salt.

The vessel is fabricated from 1.27 cm thick Inconel 600® material. Corrosion tests at LLNL have shown an acceptable corrosion rate for Inconel 600® in Na_2CO_3 and NaCl salt mixtures at operating temperature (ca. 3 x 10^{-3} ins/100 hrs). The most severe corrosion attack is due to NaCl, so the life time will be shorter at high NaCl contents. The vessel is protected against overpressure by placing close limitations on maximum feed rates, by closely monitoring the offgas system to prevent build up of salt deposits that may cause plugging, and by a rupture disk on a dedicated vessel nozzle. The rupture disc is a low pressure disk that discharges into a separate exhaust vent stack.

The vessel will expand about 3.8 cm over its length when at operating temperature. To permit this, the vessel is held from the top and mounts on a free standing structural support stand. The heaters are radiant electric type and are made up of two major subassemblies: one assembly covering the top half of the vessel and a second subassembly covering the bottom half. The heaters are separately supported from the vessel support stand. The vessel has a salt drain pipe extending from the bottom of the vessel to outside the heated zone. A plug of frozen salt will be established in the salt drain pipe, and when the spent salt is to be removed from the vessel, a separate heater will be turned on to melt the salt in the drain pipe. At that point, the entire salt contents of the vessel will discharge through the salt drain pipe into a collection pan. The collection pan is inside a special canister that contains any salt splashing and misting that may occur. After the salt has cooled, the entire canister with its salt contents is moved to the salt recycle area for extraction of the (now frozen) salt. The vessel temperature is maintained by the control

Fig. 1 Integrated MSO System



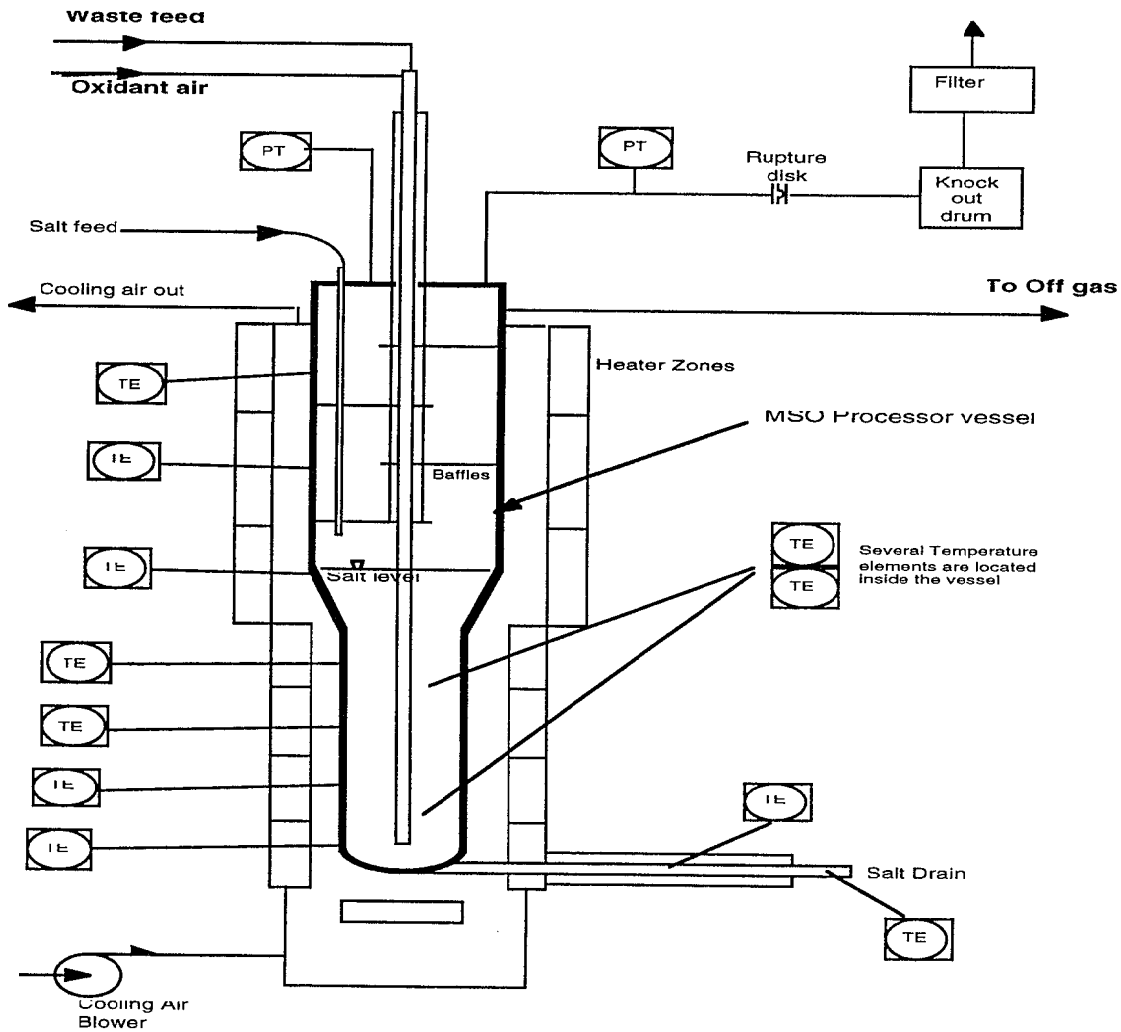


Fig. 2. MSO Reaction Vessel

system. The heaters are segregated into several zones, each of which is separately controlled to a temperature determined by sensors mounted in blocks on the outside of the vessel. When exothermic materials are being fed, the vessel must be cooled to prevent overheating. A blower is provided for this which blows ambient air though the annular space between the heaters and the vessel wall.

4.2. Off-gas System

The purpose of the off-gas system is to remove entrained salt particulates, moisture, and traces of CO and NO_x from the off-gas and ensure that clean gas exists the off-gas system. This is accomplished by the following components: a piping section with a gas-to-air cooler, an air cylinder and salt trap, a ceramic filter, a heat exchanger and condenser, an electrical heater, a HEPA filter, and catalytic converter. Figure 3 shows the off-gas system.

The off-gas exiting the reaction vessel is first cooled to 500°C by the gas-to-air cooler. The gas-to-air cooler consists of two concentric pipes with an annular gap between them. Compressed air flows through the annular gap and cools the gas flowing through the inner pipe. As the gas stream cools, the entrained salt cools and sticks to the inner pipe wall. Salt buildup is removed by a wire brush on the end of a rod that is driven and retracted by the air cylinder. The dislodged salt falls into the vessel on the forward stroke and falls into the salt trap on the reverse stroke. The smaller entrained particles are captured in the pulsating, self-cleaning ceramic filter. The ceramic filter captures particles ≥ 0.5 micrometers in size and can withstand gas temperatures up to 700°C. Six, silicon carbide filter elements are pulsed with compressed air to remove caked on salt when the pressure drop across the elements reaches 2.74 kPa (11 inches water). The captured salt in the salt trap and ceramic filter is removed by cycling double dump valves that allow the salt to fall into a drum below them. The double dump valves are used to isolate the negative system pressure from the atmospheric drum pressure. The gas is kept at about 300°C to ensure that the gas is well above the dew point (50°C) to avoid any water condensation and that the salt remains dry.

The filtered off-gas is then cooled to 100°C by a shell and tube heat exchanger using LCW. The moisture is removed when the gas is cooled to 2°C by the condenser using propylene glycol from a chiller. The gas is then heated to 30°C by an electrical heater to ensure dry gas enters the HEPA filter. The HEPA filter serves two purposes. It acts as a pre-filter for the catalytic converter and a barrier for remaining particles in the off-gas. Thus no salt particles escape the process off-gas system. The catalytic converter is designed to abate 50,000 PPM of CO and 30,000 PPM of NO_X. It converts CO into CO_2 in a catalyst bed at elevated temperatures. It also is equipped with an ammonia injection system that converts NO_X into N_2 and H_2O by selective catalytic reduction. The off-gas leaving the catalytic converter is very clean and is exhausted to a building stack via a ducting system.

4.3. Salt Recycle System

The salt recycle system, shown in Fig 4, receives spent salts from MSO processor and off-gas system. The amount of spent salt received is about 160 kg. The size of spent salt is reduced to approximately 6.3 mm by using hand tools, air-power tools, and a crusher; which are all done inside an enclosure. Small salt particles are then transferred to tank T-101 by a spiral conveyor. Salt samples will be taken during salt crushing for analysis. Salt dissolution is performed in tank T-101 using either deionized or clean recycled water. The salt dissolution step is controlled at 30–40°C by an immersion heater and a temperature controller to minimize the amount of water required. Most of mineral residues and ashes precipitates as hydroxides and oxides during the dissolution step. Chemical reagents such as sodium hydroxide, hydrochloric acid, and dithionite is used at various stages of the process to adjust pH and/or facilitate metals removal. Reagents such as Alum [$Al_2(SO_4)_3$] and activated silica is added to facilitate the coagulation & precipitation

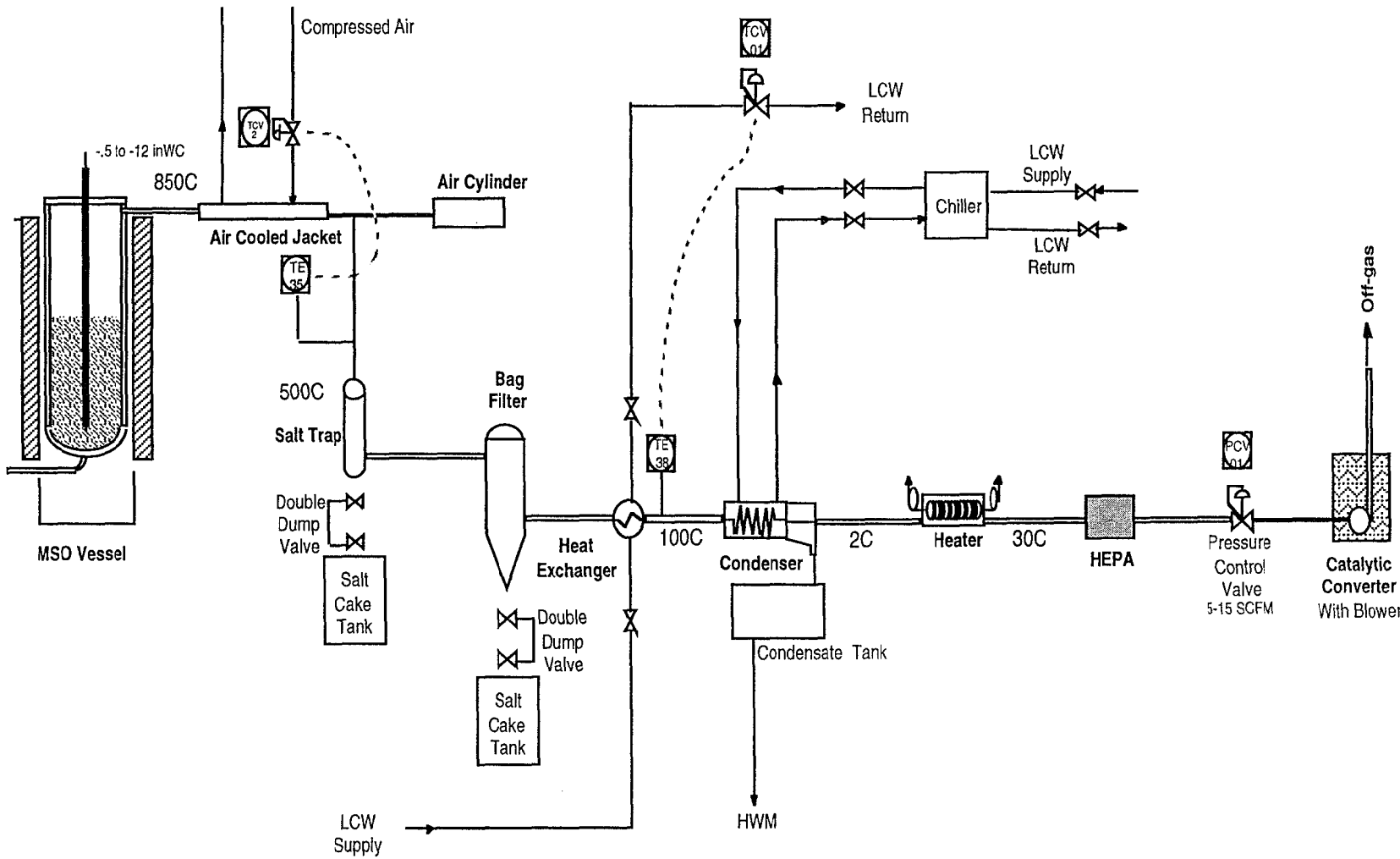


Fig. 3 Off-gas System

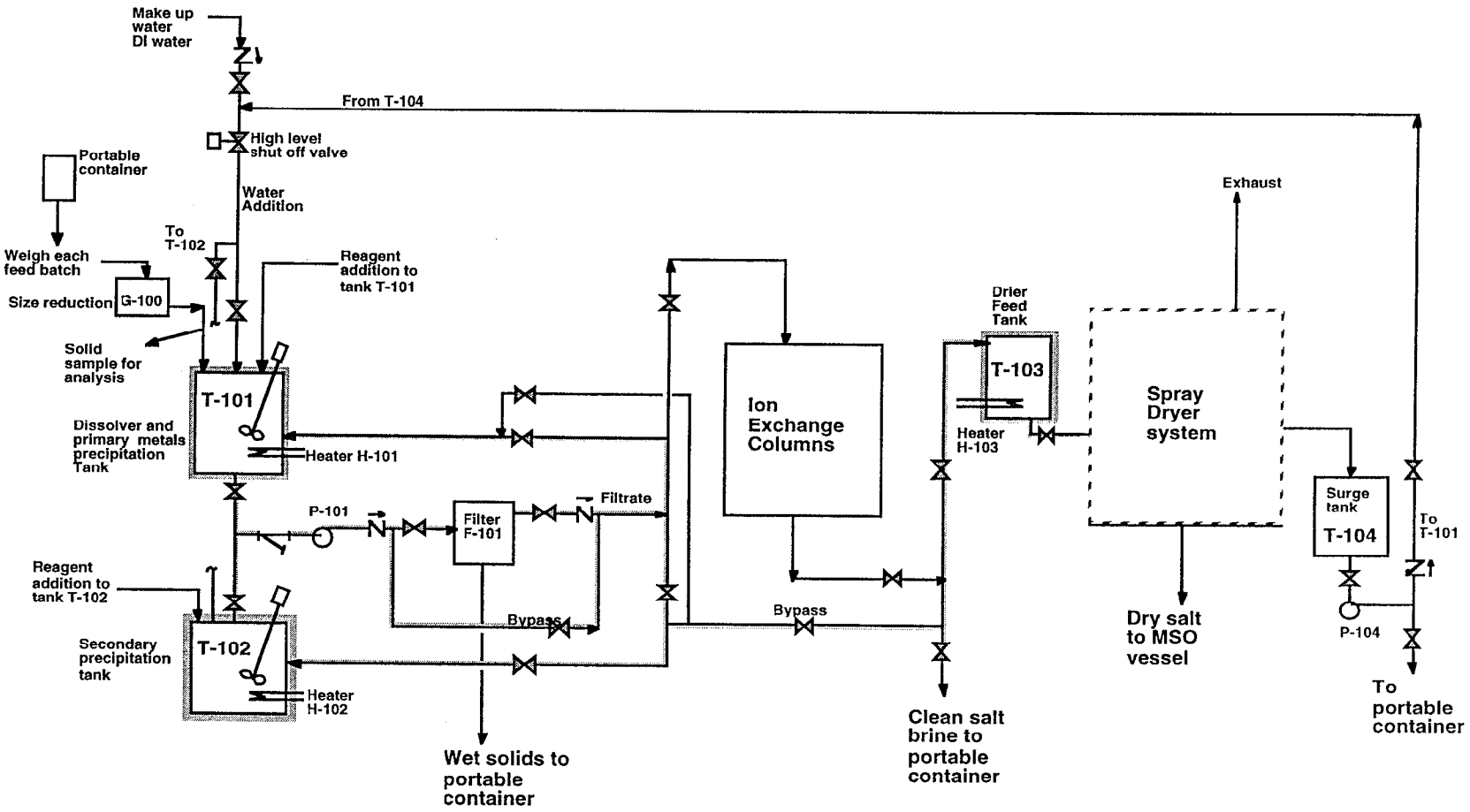


Fig. 4. Salt Recycle System flow diagram

process to avoid an excessive holding time in the dissolver tank. These reagents can be fed into the T-101 or T-102 by metering pumps or by opening the hatch.

Once precipitated, these solids can then be removed by pumping the solution through F-101. The filter has a filter element of 1 micron and efficiently removes solid particles from the salt solution. The filter element may be pre-coated with a thin layer of diatomaceous earth to facilitate the filtration process. At various stages, the filter cake is removed by opening the filter vessel and relocating the filter cartridge into the wash-off area inside the enclosure. Air and water are used to assist the cake removal. The wet cakes are then sent to the Final Forms for immobilization. The filtration operation is performed inside an enclosure

After metals precipitation, the salt solution goes to a spray dryer, ion exchange columns, and/or portable containers, depending on the concentrations of carbonate and radionuclides. If the spent salt contains high level of carbonate, then the solution is pumped to T-103 for spray drying. If it contains low levels of carbonate and traces of uranium and thorium, then the salt solution is pumped to the ion exchange columns E-101/E-102 for removal of radionuclides. In some instances, the salt solution is pumped to portable containers and shipped to Hazardous Waste Management (HWM) of LLNL.

The spray dryer is part of the salt recycle system. It receives clean salt solution from T-103. The system includes a natural gas-fired air heater, a dryer using hot air as heating medium, a cyclone separator for collecting clean dry salt, and a venturi scrubber as well as an absorber for gas cooling and dust control. The clean dry salt is collected in well-sealed drums for reuse. The air leaving the absorber passes through a HEPA filter and exhausts. The spray dryer is operated at a slight vacuum. Condensate blowdown is pumped to T-104 for reuse or discharge.

4.4. Ceramic Final Forms

Final Forms will demonstrate making a ceramic waste form containing and immobilizing the "mineral residues" isolated by the ETDP Salt Recycle system. The demonstration is at the scale of a pilot plant, the basic methods having previously been developed at the benchtop scale [Ref. 12]. Final Forms' operations are largely independent of MSO and Salt Recycle, exceptions being optimizing the filter aid used by Salt Recycle to achieve optimal waste loading of the ceramic, receiving mineral residues from Salt Recycle, and merely sharing a single facility.

The filter cake produced by the salt recycle system will contain residues from the MSO input waste stream(s), and compounds introduced by the MSO process itself and by the salt recycle process. Residues derived from LLNL wastes are expected to be dominated by Si, Al, Mg, Zn, Ca and Fe. The filter cake of the present MSO/SR demonstrations, however, will be dominated by the filter aid used in Salt Recycle and by the oxides of Cr, Ni and Fe resulting from corrosion of the MSO reaction vessel. (This is atypical of an extended waste treatment operations; it is a consequence of the small amount of waste treated in each demonstration.) Any of a wide variety of elements may be present in minor or trace amounts. The ceramic final waste form must immobilize the hazardous and radioactive elements present; both the ceramic material and the process to make it must be adaptable to the variable composition of the filter cake; and a high waste loading is desirable. The ceramic is intended to satisfy federal and California leach resistance standards.

The ceramic material is described in Section 7 and in Ref. 12. Briefly, the ceramic comprises four principle crystalline phases chosen because (1) they can be fabricated as a durable ceramic using standard and economical ceramic processing methods; and (2) because they can incorporate, either as major constituents or by ion substitution, all of the dominant elements just mentioned, and most of the hazardous and radioactive elements of concern. In an actual waste processing setting, waste loadings could be optimized by blending residue batches, but this is impractical for ETDP.

Suitable hazards controls are in place. See Ref. 13. In particular, the powder processing steps are conducted in closed equipment or in fume hoods to avoid dispersion of the powders. The quantities of offgas (H_2O, HNO_3, CO_2, CO, NO_x, SO_x) generated by the Final Forms system are far below regulatory limits, but some conditioning is done prior to release. Process control is local to each equipment item; process monitoring is direct to the Final Forms computer. (Automatic data logging was planned but has not yet been implemented.) The system is capable of producing ~2 Kg of ceramic waste form per 8-h working day, in the form of cylindrical pellets approximately 9 mm dia × 6 mm tall.

The main process steps and equipment items (*italics*) are as follows:

- Ceramic design and recipe.
- Batching: formulating a batch comprising a mixture of residues, ceramic precursors, and other reagents; done in an ordinary *fume hood.*
- Wet Milling: mixing and comminuting the batch in an *attritor*;
- Calcining: drying and calcining it in a *rotary calciner;*
- Granulation: granulating the resulting powder in a *granulator;*
- Pellet Pressing: forming pellets by cold-pressing the granulated powder in a *pellet press.*
- Sintering: sintering the pellets in a *large tube furnace.*
- Miscellaneous activities: material transfers between the various pieces of equipment, process control tests (including test sintering in a *small tube furnace*), quality control tests, and equipment maintenance and refurbishment.

These steps and the associated equipment are described below. A process functional flow diagram is given as Fig. 5, and a floor plan showing the layout of Final Forms is given as Fig. 6.

Residue Process Acceptance: Final Forms will receive containers of the mineral residues from Salt Recycle, typically in the form of an aqueous sludge (well-settled, consisting of ~3-5 L of "mud" and a similar quantity of a clear supernatant aqueous solution). The residue batch will be accompanied by written documentation of its identity, history, and prior characterization. This information is used to determine the ceramic formulation, and to determine that the residue batch conforms with the OSP and Final Forms' "Process Acceptance Criteria." Receipt of the residue is entered into Final Forms' Tracking Log.

Recipe Design & Batching: On the basis of the chemical analysis of the mineral residue, a "design" of the ceramic—meaning its phase constitution—will be chosen and a recipe for the starting mixture formulated. The components of the recipe are measured and blended in the "batching" fume hood and transferred via tubes directly to the attritor's grinding tank.

Wet Milling with Attritor: The attritor is a closed machine for wet milling. Its operation mixes the batch and comminutes it. Minor physicochemical changes occur. The slurry is continually recirculated (by a peristaltic pump) through the attritor grinding chamber. Samples are taken for process control measurements (particle size, viscosity, pH). Batch properties are adjusted by further additions of reagents. When the slurry is deemed satisfactory, it is diverted from the recirculation line and pumped directly to the calciner inlet.

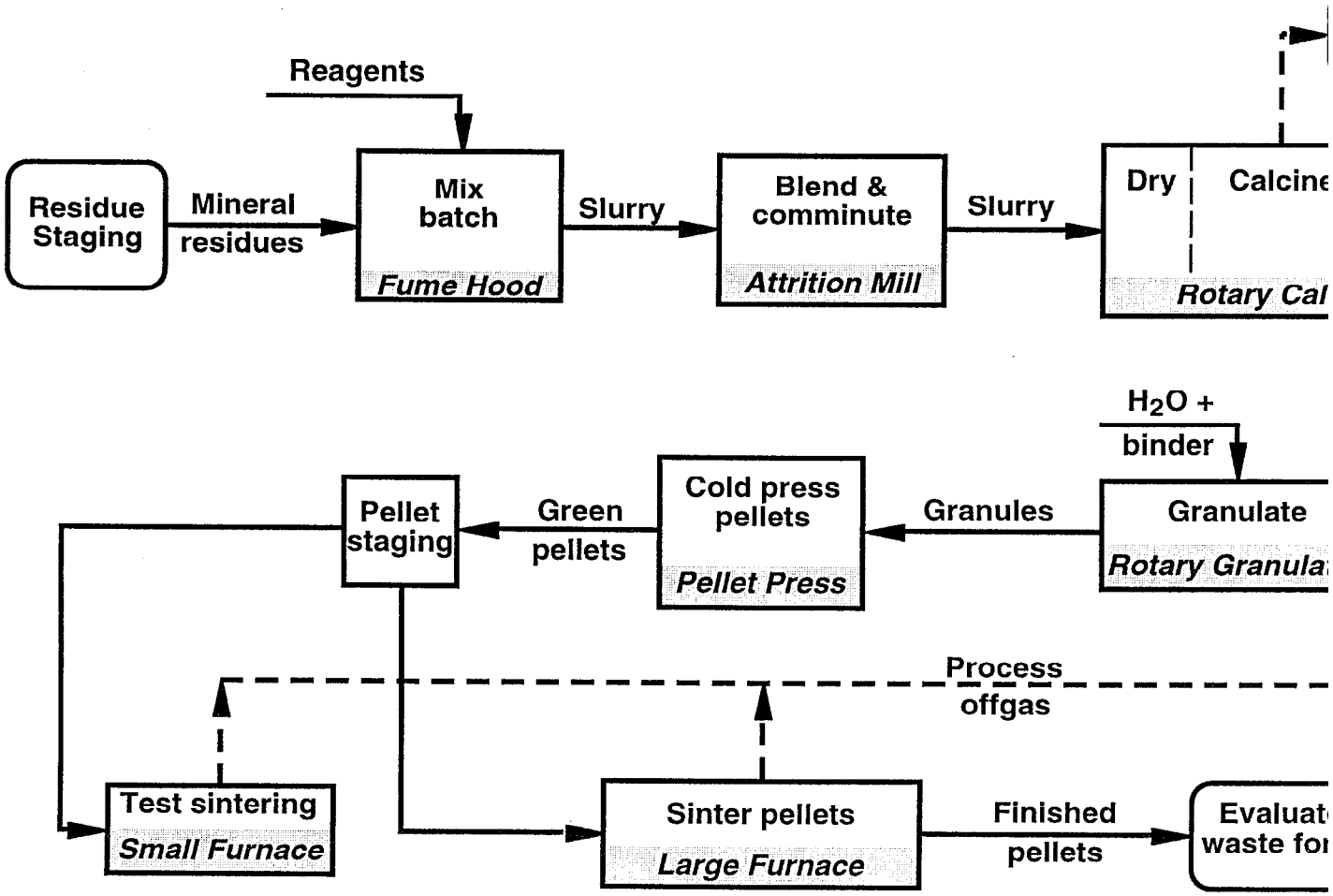


Figure 5. Ceramic waste form process functional flow diagram.
Wastewater streams generated are not shown.

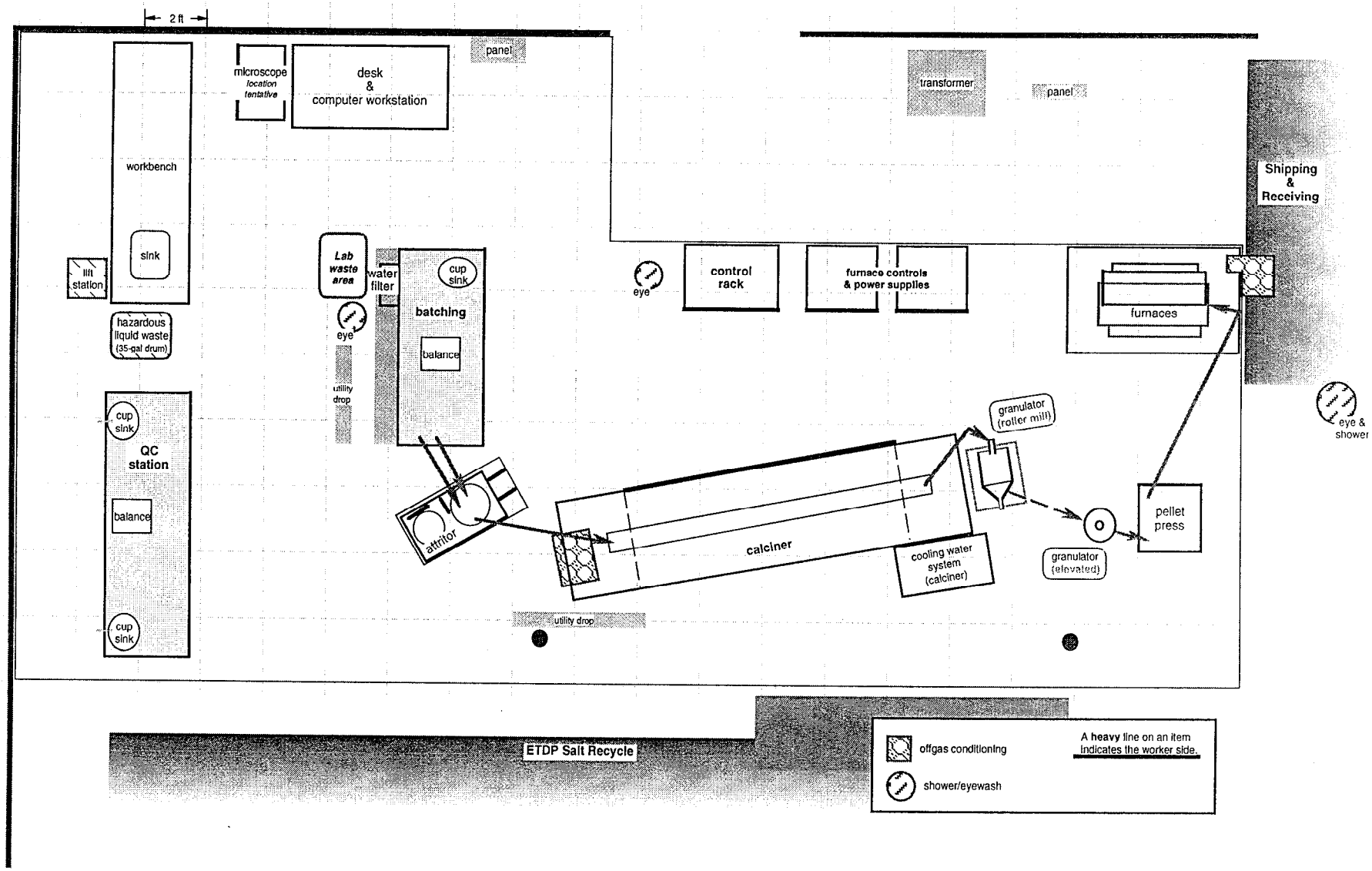


Fig. 6. Floor Plan (Final Forms)

Calcining: The rotary calciner is an inclined tube furnace with a sealed rotating process tube (tube ID 10 cm, heated length 1.2 m, 3-zone, 900°C maximum). It is equipped with an integral cooling section, with a hammer and a scraper (to deal with any caking), feed and discharge systems incorporating air-tight seals, air input and offgas removal systems, and a simple offgas conditioning system. The "charge" (i.e., the batch slurry) enters a cool portion of the process tube and translates downward through it, encountering increasing temperatures that peak at ~650°C. The batch dries, releasing water and small amounts of HNO_3 gas; hydrates, carbonates, nitrates and some sulfates decompose with the release of H_2O, CO_2, NO_x and SO_x; and solid-state reactions between batch components occur. Certain inorganic coumpounds (e.g., Tl_2O_3) will vaporize if present; these are trapped. The charge then passes through a cooling section and into the exit hopper. The "calcine" (i.e., the batch, now a powder) is released though a ball valve into a tube leading to the granulator.

The calciner operates at a slight negative pressure. Offgas is removed from a hot region within the process tube, and passes through a condenser and a local house keeping HEPA filter prior to release to the facility exhaust system. The calciner includes features designed to minimize the likelihood of steam overcoming the negative-pressure operating condition, and to minimize caking of the charge onto the process tube. In the event of a power failure, offgas is removed through a back-up system driven by a blower under emergency power, and the process tube continues to rotate to maintain the translation of the charge along it.

Granulation: Granulation is the conversion of the (potentially) dusty and/or lumpy calcine into small dust-free agglomerates. This is accomplished by tumbling the powder with small amounts of solid organic processing aids (e.g., polyethylene glycol) on a roller mill. The granulator itself is mainly a cylindrical vessel. The calcine passes from the calciner outlet downward through a flexible plastic transfer tube and through the metal inlet tube of granulator. The inlet tube is mounted in a rotary seal, allowing the body of the granulator to rotate on the mill without disconnecting the transfer tube. The outlet end of the granulator is a funnel-shaped hopper. When granulation is complete, the outlet plug is removed and a rubber hose leading to the pellet press is attached. The granulator is then elevated near the pellet press by a manual hoist, and the granulated batch flows to the press.

Pellet Pressing: The batch is cold-pressed in an automatic pellet press of the "sliding anvil" type (maximum force ~36 KN, maximum rate 150 strokes/min). Feeding, pressing, and ejection take place internally and automatically. The pressed pellets (0.45 in dia × ~0.3 in high) are removed by a vacuum pickup and dropped though a plastic tube into a container. When operating normally, the pellet press is effectively a closed system. A malfunction could, however, release loose powder at the sliding anvil mechanism; a small hood covering the top of the press minimizes dispersion. The pressing force is measured intermittently, and sample pellets are removed at intervals for process-control tests.
Sintering: Pressed pellets are, held in suitable refractory trays, are manually placed in the retort (a sealed refractory process tube) of one of the two sintering furnaces. The small furnace (1300°C, 5-zone, 7.6 cm ID, 91 cm long) is for process-control test sintering of a few pellets from the batch: each batch is different, and recycling a full batch of improperly sintered pellets would be troublesome. Production sintering is done the large (1300°C, 3-zone, 15 cm ID, 91 cm long). Operation is very similar. The temperature and process air flow is varied under automatic control through the sintering schedule. The organic additives oxidize early in the sequence. Sintering occurs over a period of about an hour at a high temperature, typically in the 1150-1180°C range. Process offgas is scrubbed prior to release through HEPA filters. The full sintering cycle from loading to unloading requires less than 24 hours.

Quality Control: The sintered pellets will be evaluated for process development and for waste form performance by Final Forms, other LLNL facilities, and external laboratories.

These include physical properties (e.g., density, strength, porosity), phase determination (X-ray diffraction), microsctructure, and leach behavior (Federal TCLP and California WET).

Archiving, Recycling, & Disposal: When all evaluations of the ceramic waste form pellets are complete, they will either be retained by ETDP as archival specimens, or will be transferred to Hazardous Waste Management for disposal. Some of Final Forms' process "wastes" can be incorporated into a subsequent ceramic batch formulation or an MSO input waste stream. Any wastes not recycled within the ETDP system are disposed of through HWM in the usual manner.

Final Forms' integrated process: The size and nature of Final Forms' equipment dictates the way in which the above steps are integrated into a single process. We refer to the total amount of a Salt Recycle residue to be processed (which may or may not be all of that produced in the Salt Recycle run) as a "batch." Final Forms will process a batch, in a semi-continuous manner, as a series of "sub-batches." The attritor can efficiently mill enough slurry for about two kilograms of waste form at a time. (There are several standard ways whereby this limit could be overcome, but this is beyond the scope of the project.) In contrast, calcining less than enough for about one kilogram at a time is problematical. Accordingly, a residue batch will be mixed (in case settling has led to segregation of the batch components) and divided into sub-batches. Each sub-batch will be mixed and milled with mineralizers and other reagents in the attritor, and the sub-batch pumped into the calciner. As soon as the attritor is free, another sub-batch will be milled. The calciner will be operated continuously. Typically, calcination of a sub-batch will be finished before milling of the next sub-batch is complete. When enough calcine has been collected in the outlet hopper of the calciner, a suitable quantitiy (~1 Kg) will be passed into the granulator and granulated. Meanwhile, additional calcine from subsequent sub-batches will be collecting in the hopper. Thus, the sub-batches become re-combined. When granulation is complete, the contents of the granulator are pressed into pellets; the granulator is charged with more powder; and another granulation step carried out. Granulation is the slowest of these steps, requiring about a day.

5. DESIGN OF EXPERIMENTS IN THE MSO OFF-GAS SYSTEM

The experiments performed in the fiscal 1998 were divided into five test series, ranging from functional testing of each hardware component to "treatability test" demonstrations with real waste streams at LLNL. Each test series is described below.

5.1. Test Series I - Operational check-out and Establish Baseline Operations

This test series started with startup testing – a "shake down" of the new pilot plant. It included functional verification of all utilities, the control system (including all safety/alarm features), and confirmation that all hardware was operational and fully functional; this included the heater, and off-gas equipment. In this test series, system operational parameters were evaluated and optimized using the liquid injector. Testing included variation of percent excess air, air/feed ratio within injector tubes, amount of cooling air required in injector to maintain injector tip temperature below 200°C, ability to control temperature within the reactor by varying heater/blower power for both endothermic and exothermic feeds, and determination of heat-up and cool-down profiles for the 160 kg salt charge (to enable programming of off-shift start-up module within control system). Materials tested were toluene, ethylene, and mineral oil that were previously tested in the Engineering Development Unit (EDU), to facilitate assessment of the effectiveness of scale-up. Testing also included a continuous 8-hour toluene run to test the system long term stability.

Organic feed rates, oxidant air flow, injector cooling air flow, injector temperature, vessel temperatures and pressure, gas flow, temperatures, and pressures in the off-gas system were closely monitored. Appendix 1 shows all the data recorded for each run (MSO Processor Data Sheet). Several gas species including carbon dioxide, carbon monoxide, nitrogen oxides, oxygen, sulfur oxides, and total organic carbon were monitored continuously with off-gas analyzers. Nitrogen oxides and carbon monoxide were also monitored downstream of the catalytic converter.

5.2. Test Series II - Tests with Liquid Organic Surrogates Containing Heteroatoms

Organic liquids containing heteroatoms were tested in the Test series II. These included toluene spiked with organics containing heteroatoms such as chlorine, fluorine, nitrogen, sulfur, and phosphorous. Examples of spikants are pyridine, dimethyl sulfoxide (DMSO), trichloroethylene (TCE), Freon 113, and dimethyl phosphate. Chlorine, fluorine, sulfur, phosphorous in the organics were converted into chloride, fluoride, sulfate, and phosphate, respectively, which stayed in the molten salt. Salt was drained from the vessel, providing surrogate test material to the salt recycle system. This series was followed by two weeks of maintenance including *in-situ* non-destructive evaluation of reactor corrosion using ultrasonic testing, inspection of rupture disc, GSS filter, and change-over to a solid injector.

For each run in the test series II, all the process data including gas species were recorded in the sheet as shown in Appendix 1. Some gas samples were also collected and sent to a laboratory for analysis of POHCs (principal oganic hazardous compounds) . This analysis provided information on the DRE of the MSO process for each individual POHC. Spent salt drained out of the reaction vessel was sent to the salt recycle system.

5.3. Test Series III - Solid Feed Injection

The objective for Test Series III was to determine essential operational parameters for the solid injector using several prototypical solid feeds. Surrogate materials included ABS plastic pellets, ion exchange resin, shredded booties and gloves, and activated carbon. For each run in the test series III, all the process data including gas species are recorded in the sheet as shown in Appendix 1. Some gas samples were also collected and sent to a laboratory for analysis. Salt containing ash was drained from the MSO vessel and sent to the salt recycle system.

5.4. Test Series IV - Tests with Radioactive-Spiked Liquids

Based on the results achieved with materials tested in test series II, surrogate organics were spiked with low-level radioactive materials such as ^{238}U/D-38. The compositions of surrogate materials mimicked the following low-level mixed waste streams at LLNL: LL-W008, LL-W009, LL-W014, and LL-W016. Salt was drained from the reaction vessel and sent to the salt recycle system for processing. A surrogate organic, toluene, was traced with a small quantity of C-14 labeled organics in order to establish accurate mass balances for carbon. Analysis of C-14 was determined using the accelerator mass spectrometry (AMS) technique.

For each run in the test series, all the process data including gas species were recorded in the sheet as shown in Appendix 1. Some gas samples were also collected and sent to a laboratory for analysis. The off-gas leaving the catalytic converter was monitored continuously for radioactivity. For the run traced with C-14, organic feed, off-gas samples, and salt were collected and sent to CAMS (Center for Accelerator Mass Spectrometry) for

analysis. This analysis determined the carbon exchange and the distribution between organic carbon and carbon in sodium carbonate (Na_2CO_3) during the oxidative destruction of organics in the reaction vessel.

5.5. Test Series V - Treatability Studies with Low-level Mixed Waste Specimens

Two real waste samples were selected from the current LLNL mixed waste inventory, RTS#1 and RTS#2. RTS#1 was chlorinated solvents (LL-W008) and RTS#2 was a PCB-contaminated waste oil (LL-W009). Both are considered hazardous and difficult to treat or dispose of. Before Series V started, the selected wastes were sampled and sent for a comprehensive analysis. The chlorinated solvent contains mostly methyl chloroform (MCM) with traces of metals and radionuclides such as uranium and tritium. The PCB-contaminated oil contained 1567 ppm PCB.

During the demonstration, toluene was added to the waste specimens for volatility control (chlorinated solvent) and for reducing the viscosity of waste oil (PCB-contaminated oil). All the process data including gas species are recorded in the sheet as shown in Appendix 1. Best Environmental, Inc., a certified off-gas handler, was contracted for the off-gas sample collection and analysis per EPA methods. After each demonstration with the real waste specimen, salt was drained out from the reaction vessel and sent to the salt recycle system for processing.

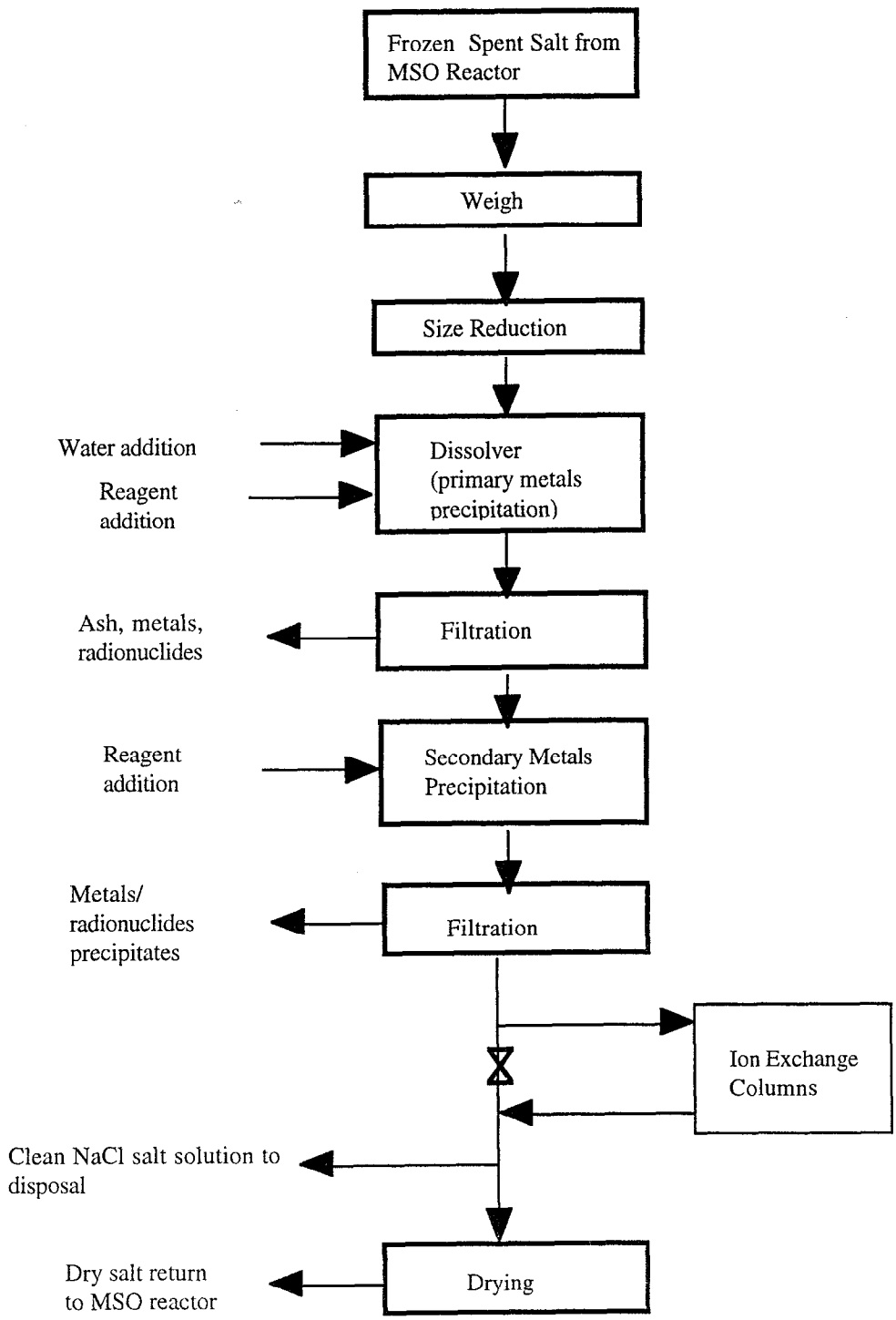
6. SALT RECYCLE EXPERIMENTS

The salt recycle system processes spent salts generated in MSO. If the spent salts contain significant levels of carbonate, the system will spray-dry the resulting clean salt solution and send the dried salt back to the MSO vessel in order to minimize the generation of secondary waste as well as to reduce cost. If the spent salts contain very high levels of chloride and are destined for disposal, the SR system can clean up the salts and remove contaminants to a degree which meets the specification acceptable for final disposal. In FY 98, there were six batches of spent salts processed in the salt recycle system, SR1, SR2, SR3, SR4, SR5, and SR6. Processing of each spent salt followed the procedure described in Section 4.3 and Fig. 7. A detailed description of the salt recycle operational procedure can be found in the operational manual [4].

SR1 was the spent salt drained from MSO after test series I and II. It was a non-radioactive salt with very low ash content . It also contained some chloride, fluoride, phosphate, and sulfate due to the types of organics fed into the reaction vessel in the test series. Traces metal compounds such as chromium, nickel and iron may exist in the salt. SR2 is the spent salt drained from MSO after test series III. It is a non-radioactive salt with some ash. The ash level in the salt, depending on the types and amounts of solid fed into the reaction vessel, is generally less than 10 wt.% in order to avoid excessive melt viscosity. SR3 was the spent salt drained after the C-14 run and activated carbon run. SR4 was spent salts drained from test series IV and was a high chloride salt. SR5 and SR6 were the salts drained after runs of RTS#1 and RTS#2, respectively. They contained low-level radionuclides such as uranium along with some chloride and fluoride.

In the salt recycle experiments, the salt solutions and the resulting solid salts were routinely analyzed for a variety of metals using ICP-OES. Additional analyses were occasionally performed for anionic species such as Cl^-, F^-, NO_3^-, SO_4^{2-}, CO_3^{2-}, and PO_4^{3-} using ion chromatography, and uranium concentrations were determined by using ICP-MS.

Figure 7 Flowsheet for Aqueous Processing of Spent Salt



7. FINAL FORMS EXPERIMENTS

As described in Section 4.4, Final Forms immobilizes solid inorganic residues of the MSO process. The residues (or surrogate residues) are blended with mineralizers and converted to a ceramic waste form. The goal is to test, demonstrate and evaluate the process and waste form for various MSO-based waste treatment scenarios.

The Final Forms system was installed and tested in FY98, and shake-down operation of individual equipment items began in July 1998 and are continuing into FY99. An OSP, based in part on this experience, was reviewed in September and formally approved in October 1998. Only the minimum I&C components have been installed.

The Final Forms system—which includes the design of the ceramic *material* and the *process* as well as the facility—was designed to demonstrate the process on the scale of a small pilot plant. The design was based on previous bench-scale experience (Ref.12). Each of the process steps described in Section 4.4 had their bench-scale analogue, but the pilot-scale processing procedures and equipment are quite different. Adapting the bench-scale process to the pilot scale requires some process development experiments.

In addition, there are significant differences between the residues to be immobilized as part of the ETDP demonstrations and the hypothetical ones on which the bench-scale development was based. Our perception of these differences changed as experience with the MSO and Salt Recycle operations accumulated. Adapting to these changed conditions will be an important part of our FY99 efforts, involving both MSO and Salt Recycle as well as Final Forms. In a broader context of a bona fide waste treatment operation, the significance of these matters depend on the nature of the operation. A brief discussion follows:

7.1 Residues, ceramic material design, and integrated operations

The ceramic waste form comprises five principal phases. These, with their base compositions and immobilization rôles are as follows:

nepheline	$Na_2O{\cdot}Al_2O_3{\cdot}2SiO_2$	[Si, K]
spinel	$MgO{\cdot}\ Al_2O_3$	[Mg, V-Ga except Cu^{1+}]
zirconolite	$CaO{\cdot}ZrO_2{\cdot}2TiO_2$	[Sr, Hf, tetravalent lanthanides and actinides including U^{4+}]
perovskite	$CaO{\cdot}TiO_2$	[Sr, Pb, trivalent lanthanides and actinides]
rutile	TiO_2	stabilizes perovskite and zirconolite

A ceramic waste form "design" is simply the specification of the relative amounts of each phase. This simply a matter of matching the phases to the filter cake composition, subject to the constraints that ~5 mole % should be rutile and each of the other four should be >10 mole %.

Input waste streams for an integrated MSO-based waste processing facility might include any or all of the following: (1) low-ash, low-halogen; (2) low-ash, high-halogen; and (3) high-ash. All these are found in LLNL's inventory of mixed wastes. To date, only low-ash streams have been treated by ETDP, and these have been in relatively small quantities. For demonstation reasons, the salt has been recycled frequently, so only small amounts inorganic solid residues had accumulated in the salt. Moreover, the "ash" content of the input waste streams was so low that the principal inorganics in the salt have been the products of corrosion of the Inconel 600® reaction vessel—oxides of Cr, Fe and Ni. (Cr and Ni are regulated elements.) The amount of "filter aid" used in Salt Recycle's filtration is pretty much a fixed volume, independent of the amount of residue solids to be trapped. Typically, ~2 Kg of diatomaceous earth (amorphous SiO_2) is used. As a consequence of

all this, the residue batches to be immobilized by Final Forms are dominated by the filter aid and, to a much lesser extent, by the vessel corrosion products.

Now this is not be the natural way to operate a "real" waste processing facility. Instead, the inorganic residues would be allowed to build up in the salt until recycling became *necessary* either because of the viscosity increase due to the suspended solids, or (when halogenated hydrocarbons are treated) the concentration of NaCl (or other sodium halide) became high enough to degrade the MSO efficiency. In either case, the filter aid would be used and reused until the amount of residue accumulated interfered with the filtration process (e.g., excessive pressures). In the case of low-ash waste streams, a residue batch would include substantial amounts of filter aid, and of oxides of Cr, Fe and Ni; and lesser—but important—quantities of the inorganic contaminants in the input waste, including hazardous and radioactive components. With high-ash waste streams, the "ash" and the filter aid would dominate the filter cake. It was for these scenarios that Final Forms' ceramic material was designed.

It is clear that a convincing demonstration of Final Forms' process must include more than just immobilizing the hazardous and radioactive consistuents in the ETDP demonstraton residues: Final Forms should also immobilize surrogate residues modeled on the normal operation of a real waste precessing facility.

Since silica is the principal component in filter cake from ETDP's demonstrations, the ceramic design requires a high fraction of nepheline. Reasonable levels of spinel and zirconolite are needed to demonstrate the capability to immobilize the corrosion products (intrinsic to the system) and uranium (the main radioisotope of interest). Obviously, a high silica content in the residue implies major additions of other mineralizers (alumina, titania, etc.). This dilutes the other components in the filter cake, thereby perversely lowering the possible loading levels of hazardous and radioactive elements. This can be alleviated by modifying the filter aid. Instead of using only silica, other mineralizers required in the ceramic formulation could be added to the diatomaceous earth to give the standard total volume of filter aid. Filtration efficiency might suffer somewhat (diatomaceous earth is exceptionally effective), but waste form loadings would be higher.

Final Forms' earlier plans were based on the mistaken notion that the filter cakes received from Salt Recycle would be quite small. We therefore planned to immobilize these at the bench scale, and to simulate the pilot-scale immobilization using a carefully matched surrogate. Such coordinated immobilizations (previously termed "Combination Tests") were dropped from the work plan.

The mineral content of residues resulting from processing laboratory trash and certain other solids are affected by their residence in the MSO vessel. Surrogates of such residues prepared by simply blending reagents may not adequately mimic the authentic residues. It is therefore desirable to demonstrate Final Forms' performance with for high-mineral wastes using residues from a special surrogate feed processed through the MSO and SR systems.

The bench-scale development work used calcined kaolin ($Al_2O_3 \cdot 2SiO_2$) as the source of SiO_2. Though diatomaceous earth provides ample silica needed chemically for the ceramic, the solid- and liquid-state reactions during calcination and sintering will be different. It is not certain that the correct phases will form in the correct amounts. (The ceramic is *not* a thermodynamically-equilibrated system.) Experimental verification is a top priority for FY99.

As noted above the concentrations of hazardous and radioactive elements in the filter cakes are very small. Final Forms tests will therefore include surrogate formulations to demonstrate process and material performance at high waste loadings. Most of the Salt Recycle filter cakes are large enough that immobilizing half would provide an adequate demonstration. The other half could be augmented with selected hazardous and radioactive

compounds to test our ability to achieve high waste loadings in a matrix of authentic MSO residues.

7.2 Startup and Test Schedule

The schedule of Final Forms activities, actual for FY1998 and planned into FY99, are as follows:

Facility installation (10/97-7/98): The main Final Forms equipment items were installed, mainly by Plant Engineering. Fabrication and installation of the process air/process offgas (PA/POG) system for the tube furnaces will continue into FY1999.

Facility startup (7/98 - 9/98): Testing of individual equipment items, initially with no processing of material. Functional tests of mechanical, thermal and I&C operation. Tests of containment functions, including fume hoods, waste water collection, and off-gas treatment. Functional tests of individual equipment items, with processing of innocuous material. Determine operational responses of equipment items (for example, the actual time and position temperature profiles of a furnace).

Equipment modifications (8/98 - continuing): As we work with the equipment, various desirable design modifications become apparent. An example is the granulator design, whose operation is proving finicky. Some modifications have been recommended by Hazards Control. The modifications will be scheduled to interfere as little as possible with the processing activities.

Process development I — Individual equipment items (7/98 – 12/99): Fabrication of ceramic waste form from residue surrogates using major equipment items individually. The purpose is to determine the process parameters of the individual process steps, to test all safety and I&C functions, and to gain experience with a variety of formulations. At first innocuous surrogates will be used, then testing will continue with low-hazard surrogates more typical of the residues expected in practice. Filter aids will be included in varying amounts to determine their influence on the process. No radioactive or particularly hazardous components will be used during this phase. Also included in this phase will be the joint experimental development of filter aids by Salt Recycle and Final Forms. Work in FY98 was mainly with the attritor, the calciner, and the pellet press.

Process development II — system integration (12/98 – 2/99): Process integration of major equipment items, initially pair-wise along with the connections between them. (An example is the attrition mill and rotary calciner along with the slurry pumping system that joins them.) This will be followed by testing and process development of the fully integrated system.

Demonstrations (2/99 –3/99): Demonstration tests of the FFM system will consist of fabricating and evaluating ceramic waste forms. Some tests will use surrogates chosen to mimic residues from waste streams which have not been tested by MSO but which appear sensible. Such waste streams include laboratory trash (paper, protective garments, etc.), machining fluids containing dispersed metals, and contaminated organic liquids. Toxic and low-activity radioisotopes (mainly ^{238}U) will be included. Immobilization demonstrations using authentic residues from MSO treatment of surrogate wastes will be done. In particular, the residue from the high-mineral waste stream surrogate will be treated/ immobilized. The main demonstrations will be the immobilization of filter cake from MSO/Salt Recycle operations.

8. DEMONSTRATION RESULTS FOR THE MSO/OFF-GAS SYSTEM

The pilot-scale MSO/Off-gas system was successfully started up in December 1997. The system had been tested with various liquid feeds including simple organics, organics containing heteroatoms (Cl,F,N,O,P,S), surrogate feeds, and LLNL real wastes. The system was also tested with several solids such as ion exchange resin, plastic, rubber, and activated carbon. The testing was based on the five test series described in Section 5.

8.1. Results of Test Series I

8.1.1. Establishing the Salt Plug

The MSO vessel has a salt drain pipe extending from the bottom of the vessel to outside the heated zone as described in Section 4.1. A mechanical plug is mounted to the end of the drain pipe. A plug of frozen salt needs to be established in the salt drain pipe before organic is fed into the vessel. The salt is either pure sodium carbonate or a mixture of sodium carbonate and potassium carbonate. The amount of salt used in the MSO vessel is 160 kg, but a lesser amount of salt (50 kg) can be used for establishing the salt plug. To confirm the existence of the salt plug, the mechanical plug was removed after the salt plug was established. Figure 8 is a picture of a salt plug.

8.1.2. Results of Testing with Simple Organics

The function of each component in the MSO/off-gas system was verified with several organic liquids: toluene, mineral oil, and ethylene glycol. Process data were recorded using datasheet as shown in Appendix 1. Toluene and mineral oil were chosen for their range of viscosities. It was expected that viscosities of most of surrogate and real wastes would be in between viscosities of toluene and mineral oil. Table 1 lists the organic liquids and run conditions for the test series.

Table 1: Run Conditions

No.	Organic Liquids	Run Conditions *
1	Toluene (50%), Mineral oil (50%)	950°C, 30% excess air
2	Ethylene glycol	30% excess air, 900 C, 925°C, 950°C
3	Ethylene glycol	950°C, varying % excess air
4	Toluene	950°C, varying % excess air
6	Toluene	950°C, 30% excess air, 8-hour run

* Note: driver air is the process air fed through the feed tube along with the organic liquid; most of the process air was fed through the oxidant air tube.

Table 2 shows the off-gas compositions from the ethylene glycol run at three salt temperatures, 900°C, 925°C, and 950°C. CO and NO_x concentrations in the off-gas were very low. It seems that, above 900°C, the effect of temperature on the off-gas quality was very small. However, it is desirable to maintain the temperature of sodium carbonate above

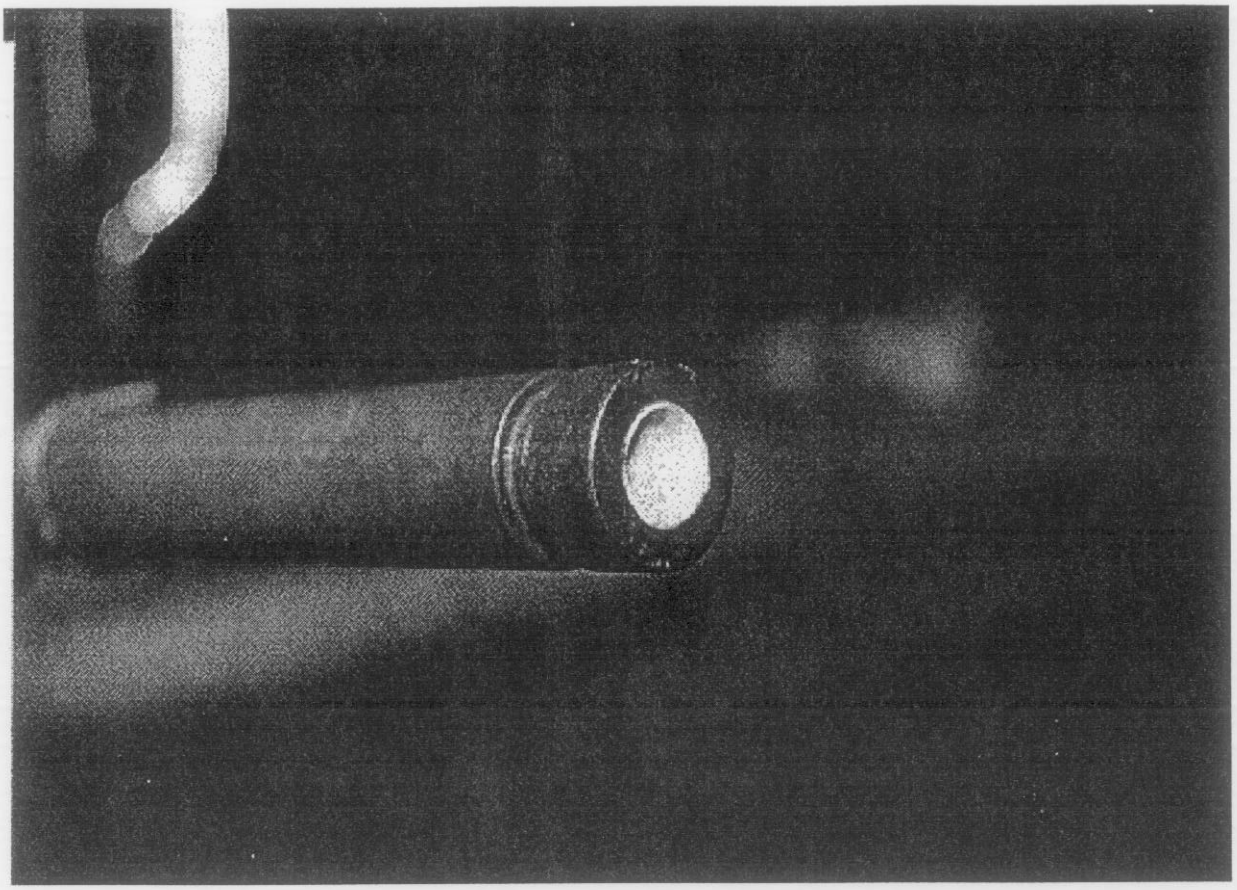


Figure 8. Salt plug in the drain pipe (picture taken on December 4, 1997)

900°C (50°C above its melting point) during the organic feed in order to avoid plugging of the injector tip.

Table 2: Effect of Temperature on the Ethylene Glycol Run

	Off-gas Composition at various temp		
Off-gas Species	900°C	925°C	950°C
CO_2, %	8.70	8.66	8.96
O_2, %	10.50	10.42	10.30
CO, ppm	13.1	7.5	9.2
NO_x, ppm	8.7	11.0	8.4
THC[3]	N/A	N/A	N/A

Note: 1. feed rate of ethylene glycol was 2.6 kg/hr,
2. 30 % excess air was used.
3. During the time of run, the THC analyzer was being serviced and therefore was not available.

For any oxidation process, excess oxygen/air is needed to maintain a good process efficiency. Higher excess air dilutes CO_2 and increases O_2 concentration in the off-gas. It also increases off-gas flow. Tables 3 and 4 show the off-gas compositions for the MSO demonstration with ethylene glycol and toluene at various % excess air, respectively. They show that the off-gas qualities were not affected by the % excess air. It is desirable to run the MSO process with at least 10% excess air or higher to overcome the fluctuation of organic feed rate.

Table 3: Effect of % Excess Air for the Ethylene Glycol Run

	Off-gas Composition at various excess air		
Off-gas Species	10%	30%	60%
CO_2, %	10.2	8.74	7.1
O_2, %	8.4	10.2	12.1
CO, ppm	9.2	8.3	8.7
NO_x, ppm	13.7	14.6	7.5
THC	1.7	1.4	2.5

Notes: 1. feed rate of ethylene glycol was 2.6 kg/hr,
2. salt temperature at 950°C.

Table 4: Effect of % Excess Air for the Toluene Run

Off-gas Species	Off-gas Composition at various excess air 10%	30%	60%
CO_2, %	10.5	8.9	7.3
O_2, %	7.8	9.9	11.8
CO, ppm	6.2	4.5	5.0
NO_x, ppm	115	97	68
THC	0.6	0.5	0.85

Notes: 1. feed rate of toluene was 1.2 kg/hr,
2. salt temperature at 950°C.

For all MSO runs in test series I, run duration was at least one hour or longer in order to reach steady state which typically occurred 30 minutes after feed starts. An 8-hour run with toluene was demonstrated for its long term stability. Figure 9 shows the off-gas composition for the 8-hr toluene run. All the data were recorded in process datasheet as shown in Table 5. Figure 9 and Table 5 demonstrate the stability of the MSO process during the treatment of toluene.

Table 7: Off-gas Composition for Feed of Toluene/Pyridine

Time, hrs	THC, ppm*	Off-gas Species, ppm or % NO_x, ppm	CO, ppm	CO_2, %	O_2, %	Vs, ft/s
0.3	0.61	967 (50)	10.7	9.9	11.1	1.0
0.8	1.1	1195 (50)	9.7	8.8	10.8	1.0
1.3	1.2	1371 (50)	10.0	8.6	10.5	1.0
1.7	1.3	370 (50)	10.3	8.4	10.6	1.0

The conversion of organic nitrogen in the feed to NO_x depends on the source of organic nitrogen and oxidation temperature. Incineration would generate higher level of NO_x than molten salt oxidation because incinerators operate at several hundred degree higher than 950°C, a typical MSO temperature for waste treatment. Pruneda et.al.[5] reported that less than 1% of organic nitrogen converted into NO_x at 750°C for the destruction of energetic materials. Table 9 shows the degrees of conversion of pyridine, nitromethane, and urea at 950°C along with several explosives at 750°C.

Fig. 9. Toluene feed at 1.2 kg/hr, 30% excess air, salt at 950 C (8 hrs run)

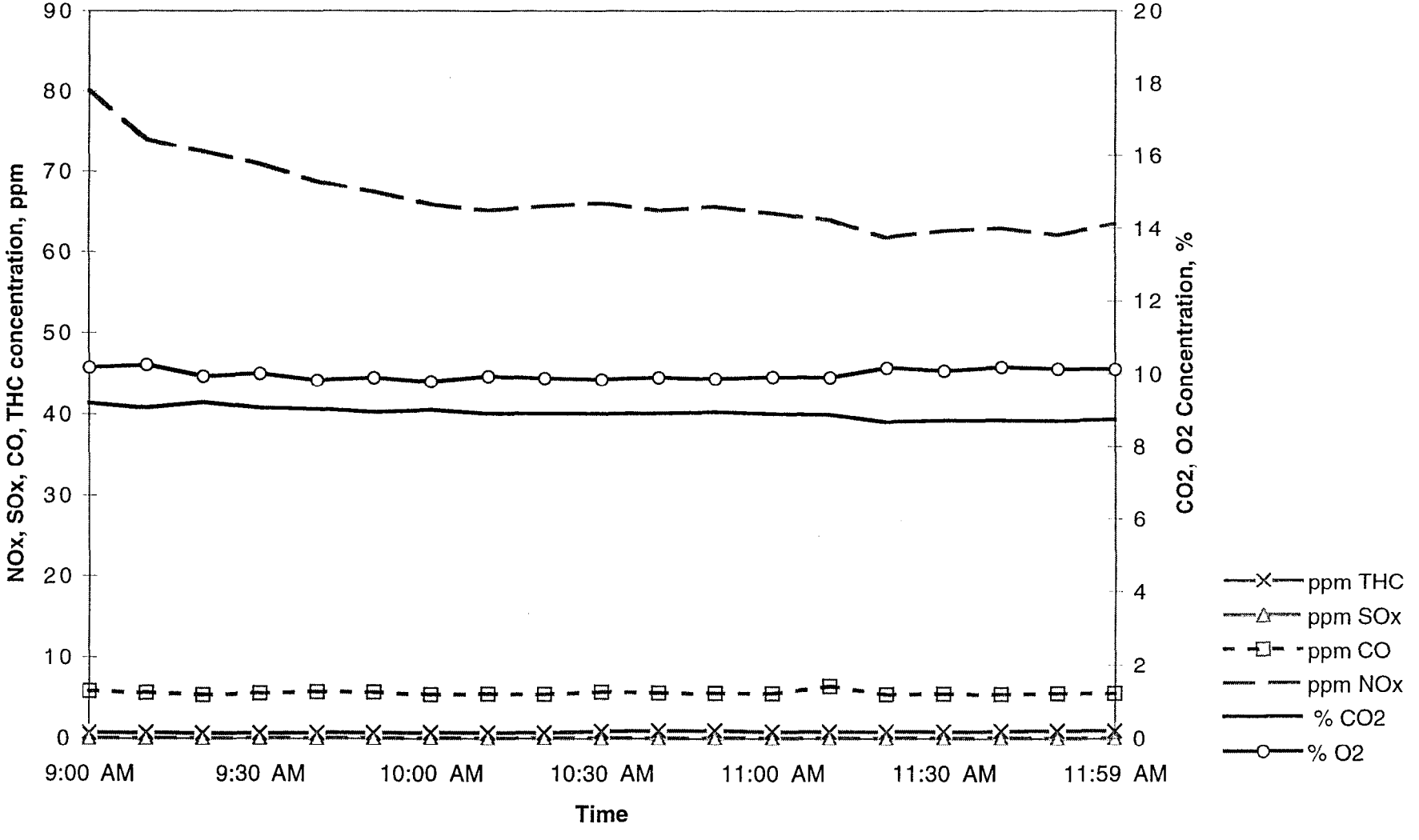


Table 5 MSO Processor Data Sheet fot Toluene Run

Date 1/27/98
Phase No. I
Run No.
Organic : Toluene

Start Time 7:50 am

Elements		Time, min 0	3 hr	4 hr	6hr	8hr
Organic Feed Rate (g/min)		0	20.2	20.2	20.2	20.2
Liquid feed pressure (psig)		N/A	19.5	19.5	19.5	19.5
Air Supply Parameters						
Driver Air Flow (slpm)		53.6	54.4	54.2	54.1	53.7
Driver Air Press (psig)		36.2	38.1	37.9	37.8	37.8
Oxidant Air FLow (slpm)		215.6	215.4	216	215.6	215.6
Oxidant air press (psig)		25.5	25.8	25.8	25.66	25.7
Cooling Air (slpm)		200	200	200	199	200
Purge Air (scfm)		0.7	0.7	0.7	0.7	0.7
Temperatures (C°)						
Salt	**TE17**	936	950	950	950	950
Exit Gas	**TE20**	618	662	662	659	658
After Soot Blower	**TE35**	336	404	403	415	416
After Salt Trap	**TE36**	172	253	257	270	274
After GSS Filter	**TE37**	78	125	134	147.3	157
After HTX	**TE38**	36	58	63	69.5	58.1
After Condenser	**TE40**	6.8	8.2	8.6	9.3	9
After Electric Heater	**TE41**	25.1	33.5	31	42.7	33.2
After Cat. converter	**TE43**	22.4	25.7	270	28.3	28.9
Injector Tip	**TE21**	876	880	880	880	881
Cooling air exit temp	**TE25**	148	193	195	195	195
Injector nozzle	**TE24**					
Pressures (inches of water)						
Vessel	**PT10/11/12**	-3	-2	-2	-1	-5
After Soot Blower	**PT13**	-2	-4	-4	-5	-5
After Salt Trap	**PT14**	-3	-5	-5	-6	-6
After GSS Filter	**PT15**	-7	-10.5	-10.5	-6	-11.4
After HTX	**PT16**	-7	-11	-11	-11.6	-11.9
After Condenser	**PT17**	-7	-11	-11	-12	-12.3
After Electric Heater	**PT18**	-10	-14	-14	-15	-15.3
After PCV01	**PT19**	-11	-15	-15	-17	-16.6
After Cat. Converter	**PT20**	-3	-3	-2	-3	-2.5
Delta P of HEPA		0.17	0.17	0.16	0.17	0.17
Off Gas Analysis						
THC (ppm)		1.7	0.79	0.9	1.3	1.6
NOx (ppm)		27.1	62.2	63.1	59.1	58.8
CO (ppm)		0.15	5.3	5.6	8.7	8.2
CO (ppm), after the cat. converter						
CO2 (%)		0.33	8.66	8.75	8.6	8.6
O2 (%)		21.37	10.19	10.01	9.9	9.9
HCl, ppm		N/A				
SOx (ppm)		2.4	0	0	0	0
Other Parameters						
Off-Gas Flow (scfm)		13.38	12.7	13.1	13.1	13.1
Blower Frequency (hz)		30	32	35	37	37

Time of activating Soot Blower
Time of GSS blowback
Time of gas sample collection

Table 8: Conversion of Organic Nitrogen into NO_x in the Molten Salt

Feed material	Reaction Temperature	% N to NO_x
Pyridine/Toluene	950°C	44.0
Nitromethane/Ethylene Glycol	950°C	34.0
Urea/EtOH/Propanol	950°C	31.0
Explosives from ref. 4		
RDX	750°C	0.05
HMX	750°C	0.11
TNT	750°C	0.45
Comp-B	750°C	0.09
LX-10	750°C	0.019
LX-16	750°C	0.14
LX-17	750°C	0.20
PBX 9404	750°C	0.25

Notes:
RDX- hexahydro-1,3,5-trinitro-1,3,5-triazine; HMX-octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazicine;TNT-2,4,6-trinitrotoluene; Comp-B-(RDX/TNT); LX-10- (HMX/Viton); LX-16- PETN/FPC 461); LX-17- (TATB/Kel F); PBX-9404- (HMX/CEF/Nitrocellulose); PETN- 2,2-bisnitoxymethyl-1,3-propanediol dinitrate; TATB- 2,4,6-trinitro-1,3,5-benzentriamine.

One of the features of the molten salt process is its ability to retain halides, sulfur, and phosphorous. They stay in the molten sodium carbonate salt bed as sodium halide, sodium sulfate, and sodium phosphate. For the test series II, the following organics containing fluorine, chlorine, sulfur, and phosphorous were tested: Freon 113 (fluorine, chlorine), DMSO (sulfur), TCE (chlorine), TBP (phosphorous). These organics were diluted with toluene and fed into the MSO process vessel at 950°C with 30% excess process air. The off-gas quality from these testing was very good. Table 9 shows the off-gas quality for the testing. The THC levels in the off-gas were very low, an indication of good process efficiency. SO_x in the off-gas was not detectable for each run since all the organic sulfur was converted into sodium sulfate and stayed in the salt bed. Salt samples were later taken for analysis of cations and anions which included fluoride (F^-), chloride (Cl^-), sulfate (SO_4^{2-}), and phosphate (PO_4^{3-}). The results of salt analysis are reported in Section 9.

Table 9: Off-gas Composition for the MSO Runs with Halides, Sulfur, and Phosphorous-containing Feeds

	Off-gas Composition for MSO Runs			
Off-gas Species	4	5	6*	7
CO_2, %	8.8	9.2	13.8	7.7
O_2, %	10.1	9.8	8.3	10.1
CO, ppm	11.6	9.4	11.1	12.3
NO_x, ppm	56.6	60.7	29.9	36.0
SO_x	0.0	0.0	0.0	0.0
THC	0.0	0.64	0.02	0.12

Note: 4-TMP/DMSO/Toluene; 5- Freon 113/DMSO/Toluene; 6-DMSO/TCE/Toluene; 7-TBP/Kerosene. * 20% excess process air was used for run 6, 30% excess process air for runs 4,5,7.

8.3. Results of Test Series III -Solids

Surrogate materials including ABS plastic pellets, shredded booties and gloves, ion exchange resin (Amberlite), and activated carbon were demonstrated. For each run in the test series III, all the process data including gas species are recorded in the sheet as shown in Appendix 1. Some gas samples were also collected and sent to a laboratory for analysis. Salt containing ash was drained from the MSO vessel and sent to the salt recycle system. Table 10 shows the run conditions for test series III. The solid feeds were fed to the MSO vessel with a vibratory feeder and an eductor and carried into the molten salt bed by the compressed air. A large excess of process air was provided for these runs to overcome the feedrate fluctuation from the vibratory feeder. A larger size of ABS pellet (3.0 to 5.5 mm) was also tested but the off-gas quality was not good, probably because this increased the residence time of the pellet in the molten salt bed to complete the oxidation process. It was found that solid particles less than 3.0 mm can be effectively treated by the MSO process if sufficient excess air is provided. The off-gas composition for these runs is shown in Table 11.

Table 10: Run Conditions

No.	Feeds	Run Conditions
1	ABS pellets (2.5 mm)	950°C, 1.45 kg/hr, 58% excess air
2	Shredded booties	950°C, 1.88 kg/hr, 65% excess air
3	Ion exchange resin (Amberlite) (0.2 to 1.0 mm)	950°C, 3.0 kg/hr, 40% excess air
4	Activated Carbon (1.2 to 2.4 mm)	950°C, 1.45 kg/hr, 30% excess air

Table 11: Off-gas Composition for the Solid Feeds

	Run Numbers			
Off-gas Species	1	2	3	4
CO_2, %	9.4	8.4	12.9	8.2
O_2, %	9.3	11.2	6.2	12.2
CO, ppm	18.6	154	17	326
NO_x, ppm	306	6.9	150	112
SO_x	0.0	0.0	0.0	0.0
THC	2.0	1.0	0.4	1.15

The values in the Table 11 were taken from the off-gas analyzer readings at steady feed rate, they varied when the feed rate fluctuated and may reach as high as 80 ppm for THC,

and 400 ppm for NO_x and CO, respectively. Figure 10 shows the off-gas composition for the MSO run with ion exchange resin. The spikes were the result of feed rate variation. Although it is desirable to have a solid feeder which can deliver a constant feed to the MSO vessel, the feed rate variation can be overcome with a large excess of process air. The higher levels of NO_x, CO, and ThC in the off-gas system can be further reduced in the catalytic converter before venting to the facility stack. Effort is underway to find an alternative means to feed organic solids to the MSO vessel, including finding a different type of solid feeder and suspend solid particles in a slurry using water or organic liquid as a carrier. This option will be further studied in FY99.

The MSO demonstration with activated carbon was based on the collaboration between the EM MSO team and the Defense Programs MSO team at LLNL. A granular activated carbon, 8 to 14 mesh size, was used as the surrogate feed. The activated carbon was fed for 4 hours at 1.5 kgs/hr followed by a 9 hours of air purge. Composition of off-gas was closely monitored with off-gas analyzers. Molten salt samples were taken during the course of demonstration and were sent for carbon analysis. It was found that the instantaneous efficiency of conversion of carbon feed to CO_2 slowly increased with time, reaching approximately 80% after 4 hours. However the overall conversion efficiency of C to CO_2 at this time was considerably lower, and we found the only way to increase it was by stopping the C feed but continuing to purge air through the reactor. Carbon analyses on salt samples taken after air purging for 2 hours and 9 hours showed that the overall carbon conversion improved to 94% and almost 100%, respectively. A more detailed description of these experiments can be found elsewhere [6].

8.4. Results of Test Series IV –Spiked Organic Liquids

In the test series IV, some surrogate organics were spiked with low-level radioactive materials such as uranium. The compositions of surrogate materials mimicked some of the waste streams at LLNL. A surrogate organic, toluene, was traced with a small quantity of C-14 labelled organics in order to establish accurate mass balances for carbon. Tables 12 and 13 show the run conditions for test series IV and off-gas compositions, respectively.

Table 12: Run Conditions for Test Series IV

No.	Feeds	Run Conditions
1	C-14 Labeled Toluene	950°C, 1.3 kg/hr, 30% excess air
2A, 2B	MCM/Toluene	900°C (A) & 950 C (B), 2.4 kg/hr, 30% excess air
3	Uranyl Nitrate &2,4 Dichlorophenol in EtOH/MCM/Toluene/Mineral oil	950°C, 1.2 kg/hr, 30% excess air
4	Perchlor	910°C, 8.2 kg/hr, 30% excess air
5	Uranyl nitrate & 2,4-Dichlorophenol in EtOH/MCM/CCl4/EG	950°C, 2.2 & 3.3 kg/hr, 30% excess air

Fig. 10 3 kg/hr Ion Exchange resin (Amberlite), salt at 950 C

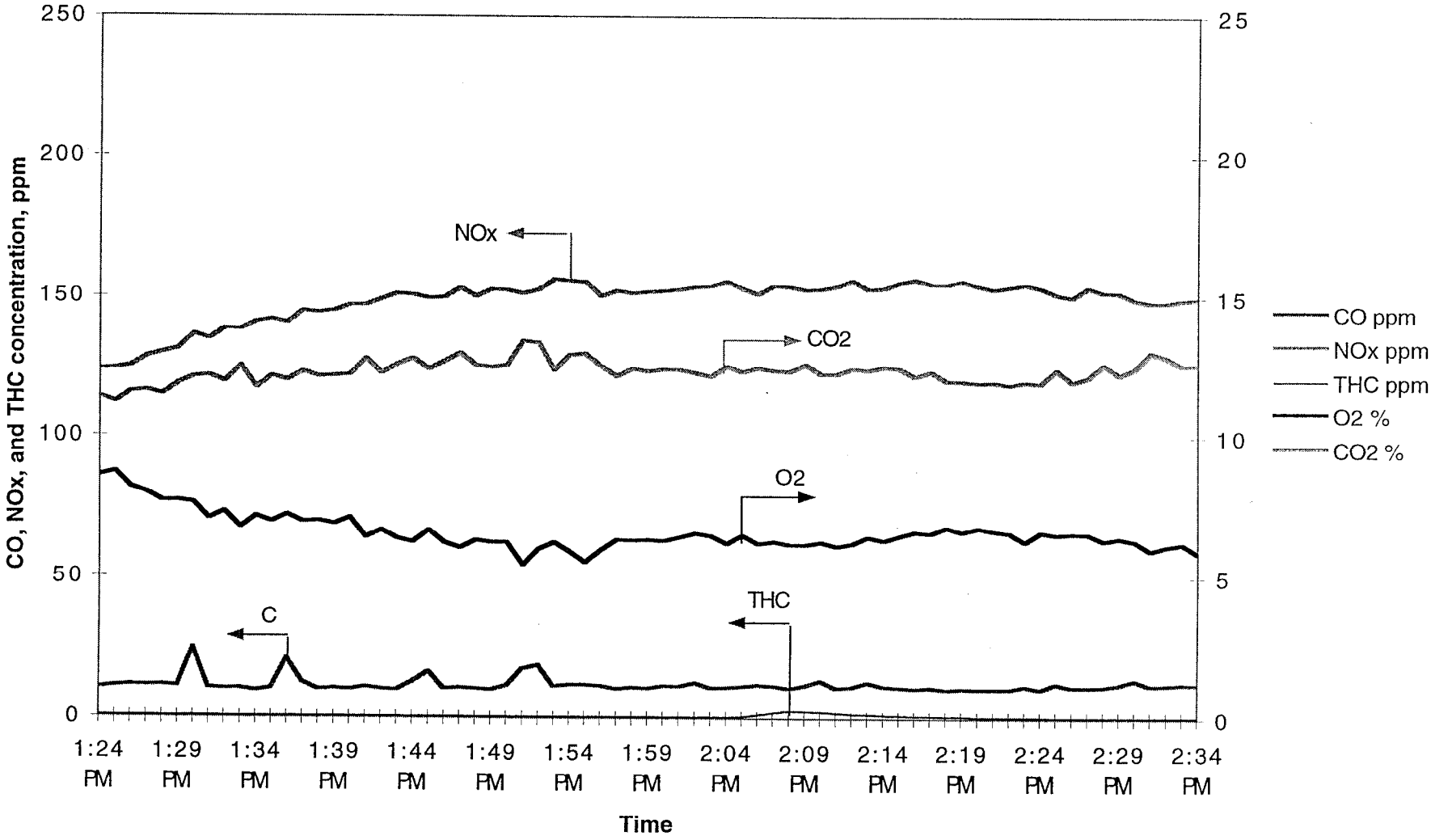


Table 13: Off-gas Composition for the Radioactive-spiked Organic Liquids

	Run Numbers					
Off-gas Species	1	2A	2B	3	4*	5
CO_2, %	10.3	11.1	11.2	7.8	16.0	8.2
O_2, %	7.8	10.0	9.6	10.1	14.3	10.3
CO, ppm	10.7	9.5	9.5	10.8	6200	11.3
NO_x, ppm	45	131	114	125	19.3	50.5
SO_x	0.0	0.2	0.2	0.0	0.0	0.0
THC	0.04	0.23	0.28	0.0	1.0	0.0

*Note: at 8.2 kg/hr of Perchlor

8.4.1. C-14 Labeled Toluene Experiment

Intuitively, carbon in the feed is expected to exchange with carbon of the carbonate salt during the oxidation process, however no experimental data was available. Therefore, in Run 1 of this test series, toluene was spiked and labeled with C-14 to 9.9 modern (or 9.9×10^{-12} fraction C-14 in carbon) and fed into the MSO process vessel in order to determine carbon exchange in the MSO process. C-14 labeled toluene was fed into the molten salt bed at 950°C for 2.83 hours followed by a 4-hr gas purge (9.0% CO_2 in air). Samples including organic feed, off-gas, and salt were taken before the run, during the run, and during the gas purge. These samples were sent to the Center for Accelerator Mass Spectrometry (CAMS) at LLNL for the analysis of C-14. Table 14 and Fig. 11 show the activity of the samples during the run. C-14 labeled toluene was fed into the MSO vessel at 21 g/min with 30% excess process air. The values in the parentheses were the percentages of C-14 fed to the MSO vessel that exchanged with the carbon atom of the carbonate molecule in the molten salt. Table 14 shows that most of C-14 fed into the MSO vessel went through carbon exchange and stayed in the salt. The percentages of the exchange was 75.3%, 77.3%, and 73.9% after 1.0 hr, 2 hrs, and 2.83 hrs, respectively. These values are very close and are well within the margin of errors in sampling and analysis. The activity of C-14 in both molten salt samples and off-gas samples increased with time, which indicates that a much longer run time is needed before a true steady state can be reached.

The feed was stopped after 2.83 hours and then was followed by a gas purge at 215 liters/min for 4 hours. The purge gas consisted of 9.0 mol% CO2 which is a typical CO2 composition in the off-gas. Gas purging slowly decreased the C-14 activity in the molten salt. Table 14 shows that the C-14 activity decreased from 1.3158 moderns to 1.0883 moderns after 4 hours of gas purge. Based on these results, it would clearly need much longer than 4 hours to completely purge and exchange the C-14 in the molten salt. The C-14 activity in the off-gas during the feed and the gas purge depends on the C-14 activity in the melt. Table 14 and Fig. 10 also show that the specific activities of C-14 in the salt and in the off-gas are almost equal, indicating that gaseous CO_2 and the carbonate salt are in thermodynamic equilibrium.

The C-14 labeled experiment has provided new and valuable technical data for the MSO process.

Fig. 11. C-14 Activity in Salt & Off-gas

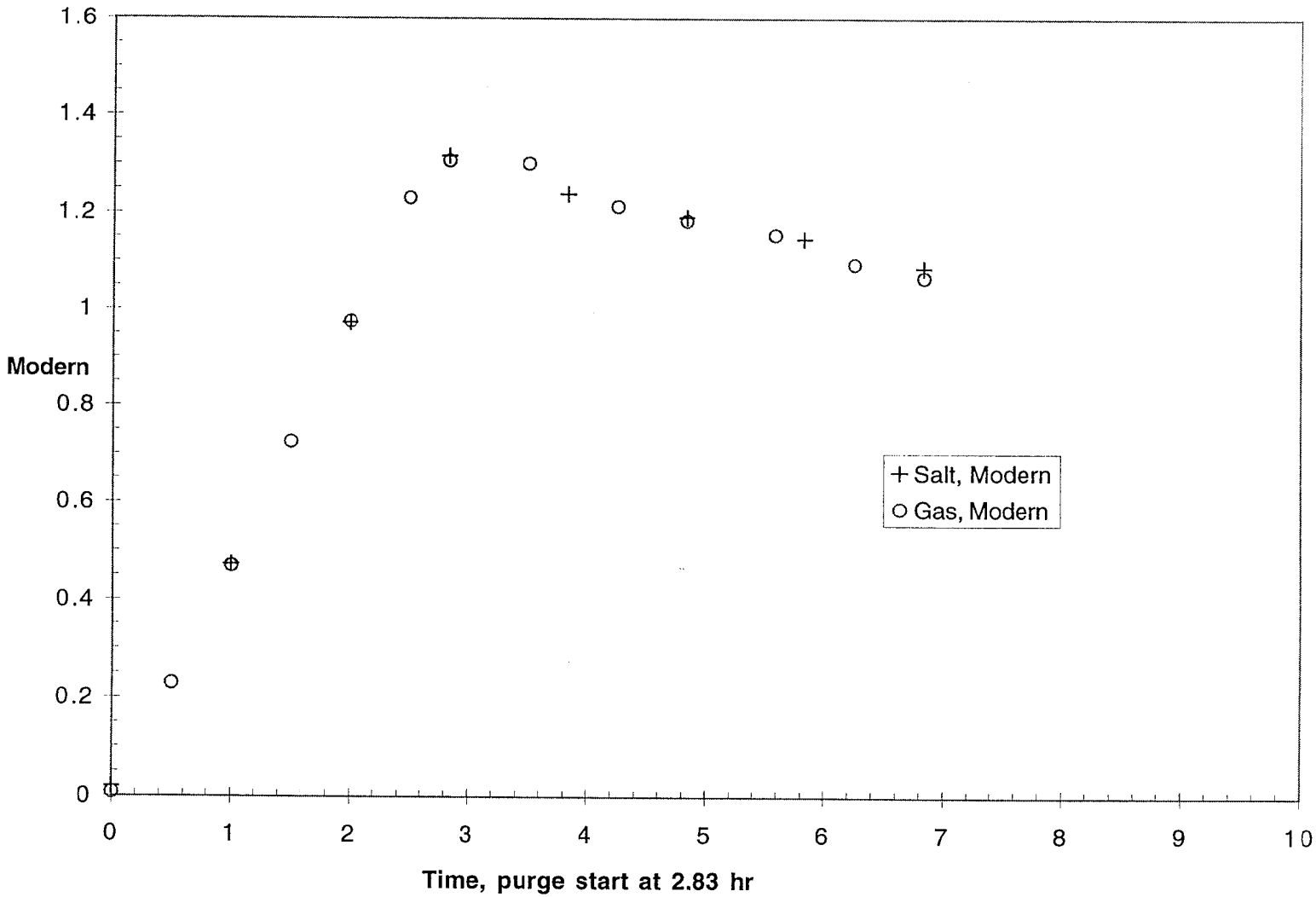


Table 14: C-14 Level in the C-14 Labeled Toluene Run

	C-14 in the sampels, modern	
Time, hour	Molten Salt Sample	Off-gas Sample
Organic Feed (9.9 modern of C-14 in the feed)		
0 (before the feed)	0.0189	0.0075
0.5	---	0.2285
1.0	0.4712 (75.3%)	0.4688
1.5	---	0.7256
2.0	0.9717 (77.3%)	0.9748
2.5	---	1.2312
2.83	1.3158 (73.9%)	1.3062
Purge Period (Organic feed terminated)		
0 (before the purge)	1.3158 (73.9%)	
0.67	---	1.3015
1.0	1.2380 (69.5%)	---
1.42	---	1.2144
2.0	1.1920 (66.9)	1.1848
2.75	---	1.1564
3.0	1.1471 (64.4%)	---
3.42	---	1.0961
4.0	1.0883 (61.1%)	1.0684

Note: The salt sample collected in the GSS filter after the run was 0.3542 modern.

8.4.2 MCM/Toluene and Perchlor Experiments

There are 4500 gallons of organic liquid wastes in the LLNL waste inventory, and most of them are chlorinated solvents (LLW-008). Over 90% of the chlorinated waste consists of MCM. One of the runs in the test series was to simulate the composition of LLW-008 waste in order to understand the feed containing mostly MCM. The salt, consisted of sodium carbonate and potassium carbonate, has lower melting point which allowed the MSO vessel to operate at lower temperature. The off-gas qualities for the MCM run at both 900°C (run 2A) and 950°C (run 2B) were very good, as shown in Table 13. Operating at lower temperature with chlorinated solvents is desirable because as chloride builds up in the

the melt, the salt becomes more volatile. Operating at lower temperature not only reduces metal corrosion but also depresses sodium chloride volatilization into the off-gas system.

Perchlorethyene, "Perchlor, "consists of 85% chlorine and was chosen to build up chloride content in the molten salt. Perchlor was fed into the MSO vessel with 30% excess air at higher feed rates than most organic feeds. The salt temperature was kept at 910°C for the run in order to reduce salt volatility. As shown in the Table 13, the THC level in the off-gas was only 1 ppm , an acceptable value despite the high CO concentration observed. The high CO concentration in the off-gas is typical at high chloride loading in the melt. The CO in the off-gas was further treated in the catalytic converter before venting through the facility stack. After the run, the high chloride salt was drained out and sent to the salt recycle system for processing.

8.4.3. Uranyl Nitrate and 2,4-dichlorophenol spiked organics (runs 3 and 5)

PCB-contaminated liquid organic waste exists in several DOE sites and presents a difficult problem due to the lack of an efficient treatment technology. Incineration can destroy PCB but it generates toxic off-gas species such dioxins and furans. A PCB-contaminated liquid waste stream, one of the difficult wastes in the LLNL waste inventory, was chosen as one of the treatability study samples. As part of test series IV, a feed containing uranium and 2,4-dichlorophenol (a PCB surrogate as a recognized precursor to the formation of dioxins/furans) was demonstrated in the MSO vessel at 950°C before the real PCB-contaminated waste was introduced.

In run 3, uranyl nitrate and 2,4-dichlorophenol were dissolved in ethanol and mixed with MCM, mineral oil and toluene in the feed container. Although it mimicked the composition of PCB-contaminated waste, phase separation occurred due to immiscibility of ethanol and mineral oil. It was fed to the MSO vessel for two hours before the injector experienced minor plugging. Pure ethanol was subsequently introduced to clear up the plugging. The off-gas quality for this run was very good.

In run 5, the surrogate waste used for the demonstration had the following formulation: Carbon tetrachloride, 4.0 wt.%; 1,1,1- trichloroethane (MCM), 4 .0 wt.%, 2,4-dichlorophenol, 1.0 wt.%, uranyl nitrate, 0.5 wt.%, ethylene glycol, 46.5 wt.%, ethanol, 45.0 wt.%. Carbon tetrachloride and 1,1,1- trichloroethane are common RCRA solvents in wastes. Uranyl nitrate and 2,4- dichlorophenol were fed in diluent streams composed primarily of ethylene glycol and ethanol for miscibility. The surrogate feed was delivered to the MSO vessel at 2.2 kgs/hr and 3.3 kgs/hr for superficial velocities of 1 ft/s and 1.5 ft/s, respectively, with 30% excess process air. Off-gas quality was monitored by off-gas analyzers during the course of the demonstration. Sample gas was also collected and sent to the Environmental Laboratory in E&ES for analysis of POHCs (principal organic hazardous compounds), dioxins, furans, and total organics. The surrogate was fed for 3.25 hrs. The system reached steady state in 30 minutes. Overall, 8.7 kg of surrogate waste was fed into the MSO vessel.

Table 15 shows the off-gas composition during the feed. Table 16 shows the POHCs in the feed and in the off-gas. A blank gas sample was also collected for reference.

Table 15: Off-gas Analyzer Readings

		Off-gas Species, ppm or %				
Time, hrs	THC, ppm*	NO_x, ppm	CO, ppm	CO_2, %	O_2, %	Vs, ft/s
0	0.0	43	3.2	0.09	21.20	1.0
0.75	0.5	103	10.8	8.13	10.4	1.0
1.25	0.0	50.5	11.3	8.16	10.3	1.0
1.75	0.0	40.5	11.4	8.24	10.13	1.0
2.75	0.0	42.8	10.8	8.47	9.89	1.5
3.25	0.0	44.2	10.6	8.5	9.72	1.5

* Detection limit of THC analyzer is 0.01 ppm. It drifted down to less than 0 ppm during the course of the experiment.

Table 15 shows that off-gas quality was very good with less than 10 ppm of CO and less than 110 ppm of NO_x leaving the MSO vessel, respectively. CO and NO_x levels in the off-gas were further reduced to undetectable levels in the catalytic converter. Other organic PICs (products of incomplete combustion) in the off-gas were not detectable. It also indicates that operating at the higher flow velocity of 1.5 ft/s would not adversely affect the off-gas quality.

Table 16 shows that DREs of the MSO process for major organics in the feed were very high, greater than 99.999%. Testing performed with the bench scale MSO unit in 1994 at Oak Ridge National Laboratory yielded similar results [7]. Dioxins and furans in the off-gas were not detectable.

8.5. Results of Test Series V- Treatability Study

8.5.1 Description

Two real waste specimens were chosen for the MSO treatability study in FY98. These specimens were received from the Hazardous Waste Management Division at LLNL (waste stream numbers LL-W008 and LL-W009). The first specimen (RTS #1) was chlorinated solvent and consisted of mainly 1,1,1-trichloroethane (MCM) with traces of metals and low-level of radionuclides. The second specimen (RTS#2)was PCB-contaminated waste.

Table 17 shows the composition of these two specimens. Treatment of five gallons of each specimen was successfully demonstrated in the MSO process vessel in August 1998. Off-gas was monitored continuously by off-gas analyzers installed in the off-gas system during the course of the demonstration. In addition to the continuous off-gas monitoring, a comprehensive gas sampling was performed per EPA methods and handled by the Best Environmental, Inc., a certified firm. Gas sampling was conducted from the sampling ports located on the 1.375" i.d. inlet and outlet of the GSS filter and from the catalytic converter 4" i.d. outlet stack venting emission from the MSO process. The sampling ports were located to meet EPA criteria (8 duct diameter downstream and 2 duct diameter upstream from any points of flow disturbance). The source test methods and test locations used for each waste feed are summarized in Table 18. Descriptions of each test method can be found in the report (Appendix 2) submitted by the Best Environmental, Inc.

Table 16. Destruction and Removal Efficiency for the MSO Demonstration with Uranium and 2,4-Dichlorophenol-spiked Organics

Conditions: 950 C, 30% excess air

Component	In the feed, g/min		In the off-gas, g/min		DRE, %, minimum		ORNL Test
	1 ft/s	1.5 ft/s	1 ft/s	1.5 ft/s	1 ft/s	1.5 ft/s	1.5 ft/s
Ethylene Glycol	16.633	24.950	1.44E-06	1.01E-06	99.999991	99.999996	N/A
Ethanol	16.267	24.400	1.44E-06	1.01E-06	99.999991	99.999996	N/A
CCl4	1.192	1.788	1.44E-06	1.01E-06	99.999879	99.999943	99.999988
MCM	1.450	2.175	1.44E-06	1.01E-06	99.999901	99.999954	99.999985
2,4-dichlorophenol	0.367	0.550	1.44E-06	1.01E-06	99.999607	99.999816	99.998283
Total	35.908	53.863					

Dioxins & Furans were not detectable.

Other organic PICs (products of incomplete combustion) were not detectable.

DRE = (1- organic in the off-gas/organic fed to the MSO vessel)*100%

Note: GC/MS was used for off-gas sample analysis.
GC/MS Detection limit is 25 nanogram.

Table 17

Real Test Specimens for MSO Treatability Study in FY 98

	RTS #1 Chlorosolvent LL-W008	*RTS #2 Oil/PCB* LL-W009
chloroform (g/L)	0.1	ND
1,1-dichloroethane (g/L)	0.5	ND
1,2-dichloroethane (g/L)	0.5	ND
1,1-dichloroethene (g/L)	20	ND
dichloromethane (g/L)	1.4	ND
tetrachloroethane (g/L)	40	ND
toluene (g/L)	0.1	2.9
dichloroethene	ND	1.7
trichloroethene (g/L)	10	ND
1,1,2-trichloro, 1,2,2 trifluoroethane (g/l)	28	14
methylchloroform (g/L)	1226.25	11
Sb (mg/L)	0	ND
Ba (mg/L)	1.5	2.6
Be (mg/L)	8.2	ND
Cd (mg/L)	0	ND
Cr (mg/L)	1.3	0.38
Co (mg/L)	0.2	ND
Cu (mg/L)	11	1.7
Pb (mg/L)	11	7.4
Mo (mg/L)	2.5	0.3
Ni (mg/L)	2	ND
K (mg/L)	4	ND
Ag (mg/L)	0.3	0.07
U (mg/L)	20	11.5
V (mg/L)	3.1	ND
Zn (mg/L)	5.3	2.3
Hg (mg/L)	0.04	0.35
hydraulic oil, (g/L)	None	862.5
PCB, mg/L	None	1567
Gross Alpha (nCi/L)	7.26	7.8
Gross Beta (nCi/L)	11.4	0.85
(Tritium (nCi/L))	33.1	38

Table 18: Test Methods and Locations for the Treatability Study

Test Location	Parameters	Test Methods	Runs	Duration, min.
GSS Filter Outlet	Filtable Particulate	EPA Method 17	3	60
	Radionuclides	EPA Method 114	3	60
	Volatiles (VOST)	EPA Method 30	9	20
	HCl	EPA Method 50	3	60
	DSCFM	EPA Method 1-4	3	60
GSS Filter Inlet	Dioxins/Furan, PCB*	EPA Method 23	3	180
	Semi-Volatiles (MM5)	EPA Method 10	3	180
Catalytic Converter Outlet	Dioxins/Furan, PCB*	EPA Method 23	1	180
	Semi-Volatiles (MM5)	EPA Method 10	1	180
	Volatiles (VOST)	EPA Method 30	3	20
	Radionuclides	EPA Method 114	1	60

* PCB only for RTS#2.

8.5.2. Results of MSO Demonstration with Chlorinated Solvent (LL-W008)

The specimen was sampled and transferred from the waste container to the feed tank. Toluene was then added to the feed container under mixing to prevent phase separation during the feed to the MSO vessel. The waste liquid was pumped into the MSO vessel at 2.5 kg/hr for 14 hours with 30% excess process air. The longer run was chosen to meet the time requirement for gas sampling. Table 19 shows the off-gas composition at steady state for both RTS#1 and RTS#2. Concentrations of CO and THC in the off-gas for RTS#1 were 15.6 ppm and 0.2 ppm, respectively, which were much less than 100 ppm for CO and 20 ppm for THC, the current standards for mixed waste incinerators [8].

Table 19: Off-gas Composition for RTS#1 and RTS#2*

	Run Numbers	
Off-gas Species	RTS#1	RTS#2
CO_2, %	8.1	7.3
O_2, %	12.0	10.1
CO, ppm	10.2	15.6
NO_x, ppm	56.4	27.3
SO_x	0.0	0.0
THC	0.2	0.0

*The numbers were taken directly from the readings of the off-gas analyzers.

Table 20 shows feed rates to the MSO vessel and emission rates and DREs for principal organic hazardous contituents (POHCs) along with total dioxin/furan, volatile organics, semi-volatile organic, particulate, gross alpha, gross beta, tritium and HCl in the off-gas. There were six POHCs in the RTS#1 feed: MCM, 1,1-dichloroethene, tetrachloroethene, trichloroethene, trichloro-trifluoroethane, and toluene. The DREs for these six POHCs were greater 99.999%, an indication of excellent process efficiency for the demonstration. The particulate emission rate was 0.00011 lbs/hr at average off-gas flow rate of 13.5 dscfm (dry standard cubic ft per min) or 0.00006 g/ft^3. This is much less than the particulate loading of 0.08 g/ft^3, the standard for mixed waste incinerators. The low particulate loading in the MSO off-gas system is not surprising because the GSS filter can effectively remove most particles from the gas stream. Table 20 also shows that the molten salt retained and trapped gross alpha and gross beta very well. The percentages of gross alpha and gross beta which was fed into the MSO vessel going into the off-gas were 0.32% and 0.12%, respectively. HCl level in the off-gas was less than 0.0016 g/hr, which indicated that most of the chlorine in the feed (about 50 wt.% of the liquid feed or 21 g/min of chlorine) has been converted into sodium chloride as expected and stayed in the salt bed. Sodium chloride is ten times more volatile than sodium carbonate and its vapor would carry over to the off-gas system. The concentration of sodium chloride vapor at 950°C is 0.014 g/ft^3 [9]. Most of the sodium chloride vapor condensed in the air-cooled jacket of the off-gas system and was pushed back to the MSO vessel by the salt brush. Some of it may end up in the salt trap and GSS filter. After the run, a salt sample was taken from the reactor and analyzed for its chloride content; the sodium chloride composition after feeding chlorinated solvent for 14 hours was found to be 30 wt.%.

In addition to analyzing the off-gas for the feed compounds, EPA method 10 and method were used to determine the emissions of semi-volatile organics (boiling point >100°C) and volatile organics boiling point <100°C), respectively. Table 4 and Table 6 in the Appendix 2 show the emissions of each individual semi-volatile organic and volatile organic for RTS#1. Total emissions of the semi-volatile organics from RTS#1 was less than 91.376 µg/min and total emissions of volatile organics was less than 31.568 µg/min, respectively.

Dioxins and furans are a group of related compounds which are suspected of having harmful effects in humans. Laboratory tests have shown that 2,3,7,8-TCDD (2,3,7,8-tetrachlorodibenzo-para-dioxin), one of most toxic compounds in the group, can cause cancer and toxic effects in laboratory animals. Hence their emissions from a thermal treatment process are subjected to strict regulations. EPA proposed that the regulatory limit for dioxin and furan emissions from hazardous waste treatment systems be 100 pg/m3 toxic equivalence quotient (TEQ). The toxic equivalence factor (TEF) of a particular dioxin or furan is defined as the ratio of its toxicity to the toxicity of 2,3,7,8-TCDD, which has a TEF of 1.

Table 21 shows the results of dioxin and furan emissions. Gas samples were taken from the GSS filter inlet and the outlet of the catalytic converter. The table shows the emission rate and concentration of each individual dioxin and furan and its TEF and TEQ. TEQ is the concentration of each individual dioxin and furan multiplied by its TEF. As shown in the table, the total dioxin and furan emissions from the GSS filter inlet and the catalytic converter outlet were 18.534 pg/m^3 TEQ and 17.093 pg/m^3 TEQ, respectively. These emissions are well below the EPA proposed regulatory limit of 100 pg/m^3.

Table 20: Feed Rates, Emission Rates, and DREs for RTS#1

Test Parameter	Feed Rate to the MSO Vessel	Emission Rate	DRE %
MCM	24.98 g/min	<0.542 µg/min	>99.999998
1,1-dichloroethene	0.41 g/min	1.067 µg/min	99.99974
Tetrachloroethene	0.81 g/min	<0.175 µg/min	>99.999978
Trichloroethene	0.20 g/min	<0.197 µg/min	>99.99998
Trichloro-trifluoroethane	0.57 g/min	<4.372 µg/min	>99.999233
Toluene	14.69 g/min	3.775 µg/min	99.999974
Total PCB	None	None	N.A.
Total Dioxin/Furan	None	56.061 pg/min	N.A.
VOST Volatiles	N.A.	<31.568 µg/min	N.A.
Semi-volatiles	N.A.	<91.376 µg/min	N.A.
Particulate	N.A.	0.000111bs/hr	N.A.
Gross Alpha	9,000 pCi/hr	28.55 pCi/hr	N.A.
Gross Beta	14,100 pCi/hr	16.73 pCi/hr	N.A.
Tritium	41,070 pCi/hr	7688 pCi/hr	N.A.
HCl	N.A.	<0.0016 g/hr	N.A.

Table 21: Results for Dioxin and Furan Emissions for RTS#1

Species	TEF	@ GSS Filter Inlet, pg/min	@ GSS Filter Inlet, pg/m3	TEQ pg/m3	@ Catalytic Converter Outlet, pg/min	@ Catalytic Converter Outlet, pg/m3	TEQ pg/m3
2,3,7,8-TCDD	1	4.941	12.973	12.973	5.108	10.941	10.941
TCDF	0.1	4.033	10.583	1.058	5.325	11.407	1.141
PeCDF	0.05	7.318	19.214	0.961	10.216	21.882	1.094
HxCDF	0.1	2.359	6.201	0.620	2.391	5.121	0.512
HpCDF	0.01	0.772	2.034	0.020	1.195	2.561	0.026
OCDF	0.001	1.536	4.047	0.004	0.967	2.072	0.002
PeCDD	0.5	1.921	5.048	2.524	2.934	6.285	3.143
HxCDD	0.1	0.892	2.351	0.235	0.880	1.886	0.189
HpCDD	0.01	2.219	5.854	0.059	1.087	2.328	0.023
OCDD	0.001	30.07	79.599	0.080	10.542	22.581	0.023
		56.061	147.904	18.534	40.645	87.064	17.093

Figure 12 shows the mass balance for the MSO demonstration with the chlorinated solvent waste stream. This assumes an integrated operation of the MSO/off-gas system, the salt recycle system, and the ceramic final forms at steady state. The feed rate of organic liquid is assumed at 2 liters/hr (2.31 kg/hr) along with traces of metal and radionuclides. The amount of air required for the process including purge air, and oxidant air, is 887 moles/hr

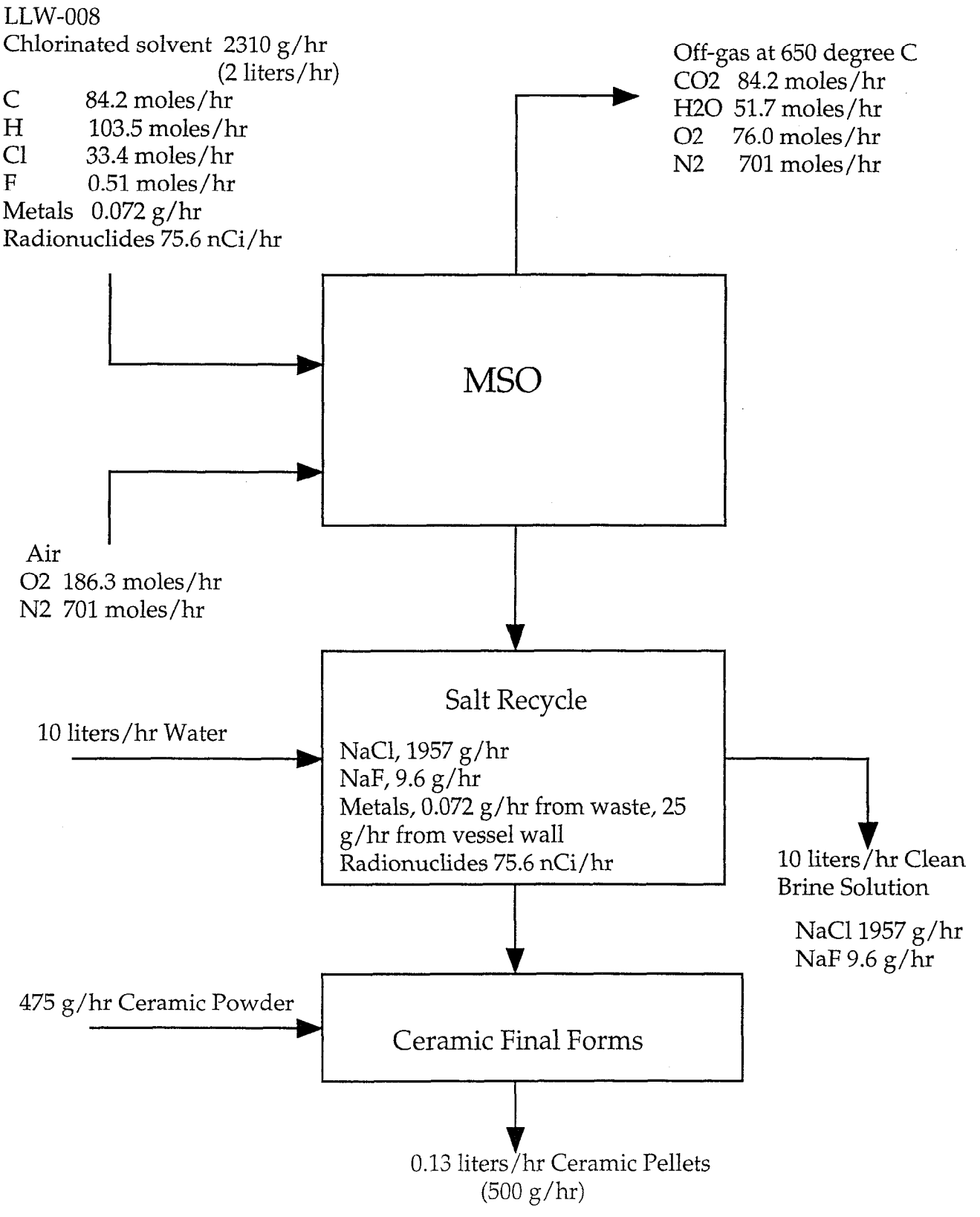


Fig. 12. MSO Flow balance for feed stream LLW-008 (Chlorinated Solvents)

and the off-gas discharge rate is 913 moles. Assuming continuous salt withdrawal from the MSO system to the salt recycle system, the water required to process the spent salt would be 10 liters/hr. The salt recycle process discharges 10 liter/min clean salt brine solution which consists of sodium chloride and sodium fluoride. Metals, metal oxides, and radionuclides are sent to the ceramic final forms system to generate ceramic pellets. As shown in the diagram, 475 grams of ceramic powder is required to stabilize the waste stream from the salt recycle system. As a result, 0.13 liters/hr of ceramic pellets would be generated.

8.5.3. Results of MSO Demonstration with PCB-Contaminated Organics (LLW-009)

PCB-contaminated wastes are difficult to treat by incineration due to the formation of dioxins and furans, cancer-causing agents, at the incineration temperature, which is typically above 1200°C. To demonstrate that MSO is an efficient alternative to treat these wastes, 5 gallons of a PCB-contaminated waste specimen (RTS#2) was fed into the process vessel as part of the treatability study. The main objective of the experiments was to show that dioxin and furan emissions from the system were below the proposed regulatory limit of 100 pg/m^3 gas as 2,3,7,8-tetrachlorodibenzo-para-dioxin equivalents or toxic equivalence quotient.

The PCB-contaminated waste was delivered to the MSO facility from the Waste Management Division of LLNL in a five-gallon container. The waste was sampled and sent for analysis. Table 17 shows the composition of the waste. Toluene was used as a diluent to reduce the viscosity of the waste for the ease of feed delivery. The waste, containing mostly hydraulic oil with over 1000 ppm PCB and traces of metals and radionuclides was fed into the MSO system at 1.1 kg/hr along with 30% excess air for 13 hours. The molten salt bed, containing 160 kg sodium carbonate, was controlled at 950°C during the course of the demonstration. The GSS (gas/solid separation) filter was backflashed with compressed air periodically to prevent excessive buildup of salt cake in the filter element. CO_2, O_2, CO, NO_x, SO_x in the off-gas were continuously monitored with off-gas analyzers. Sampling was conducted from the sampling ports located on the inlet and outlet of the GSS filter and from the catalytic converter outlet. The sampling ports were located to meet the 8 duct diameter downstream and 2 duct diameter upstream from any points of flow disturbance criteria. Best Environmental, Inc. handled the off-gas sampling operation during the demonstration. All the collected samples were sent to EPA-certified laboratories for analysis.

The off-gas quality, as shown in Table 19 was very good with less than 50 ppm NO_x, less than 20 ppm CO, and nondetectable THC in the off-gas. Table 22 shows that feed rates and emission rates of POHCs, total dioxins and furans, volatile organics, total semivolatile organics, particulate, gross alpha, gross beta, and HCl. The particulate emission rate was 0.0000034 lbs/hr at average off-gas flow rate of 13.8 dscfm or only 0.0000016 g/ft^3. The destruction efficiencies of the POHCs were greater than 99.99%.

Table 22: Feed Rates, Emission Rates, and DREs for RTS#2

Test Parameter	Feed Rate to the MSO Vessel	Emission Rate	DRE %
MCM	0.168 g/min	<0.291 µg/min	>99.999827
1,1-dichloroethene	0.025 g/min	1.073 µg/min	99.99571
Tetrachloroethene	N.A.	<0.166 µg/min	N.A.
Trichloroethene	N.A.	<0.187 µg/min	N.A.
Trichloro-trifluoroethane	0.213 g/min	<4.151 µg/min	>99.99805
Toluene	2.78 g/min	1.069 µg/min	99.999962
Total PCB	0.0233 g/min	<0.0414 µg/min	>99.99982
Hydraulic oil	14.98 g/min	N.A.	N.A.
Total Dioxin/Furan	None	108.86 pg/min	N.A.
VOST Volatiles	N.A.	<17.82 µg/min	N.A.
Semi-volatiles	N.A.	<95.854 µg/min	N.A.
Particulate	N.A.	0.000034 lbs/hr	N.A.
Gross Alpha	8,140 pCi/hr	15.53 pCi/hr	N.A.
Gross Beta	890 pCi/hr	0.961 pCi/hr	N.A.
Tritium	39,700 pCi/hr	3,564,582 pCi/hr	N.A.
HCl	N.A.	<0.0015 g/hr	N.A.

Table 23 lists the emission rates of each dioxin and furan, the toxicity equivalent factor (TEF), and its toxic equivalence quotient (TEQ). Total TEQs of dioxins and furans in the GSS filter inlet and the catalytic converter outlet were 38.743 pg/m3 and 9.338 pg/m3, respectively. These values are again below 100 pg/m^3, the EPA proposed regulatory limits.

Table 23: Results for Dioxins and Furan Emissions

Species	TEF	@ GSS Filter Thlet, pg/m3	TEQ pg/m3	@ Catalytic Converter Outlet, pg/m3	TEQ pg/m3
2,3,7,8-TCDD	1	22.301	22.301	7.506	7.506
TCDF	0.1	78.954	7.895	3.503	0.350
PeCDF	0.05	50.310	2.516	5.505	0.275
HxCDF	0.1	12.521	1.252	1.426	0.143
HpCDF	0.01	4.204	0.042	1.051	0.011
OCDF	0.001	2.742	0.003	1.776	0.002
PeCDD	0.5	8.527	4.264	1.877	0.939
HxCDD	0.1	3.593	0.359	1.001	0.100
HpCDD	0.01	4.684	0.047	1.101	0.011
OCDD	0.001	64.379	0.064	2.352	0.002
		Total TEQ	38.743		9.338

Note: The oxygen concentration in the off-gas was 10.1 vol.%. Volume of off-gas sample collected was about 4 m^3.

Figure 13 shows the mass balance for the MSO demonstration with PCB-contaminated waste oil. This again assumes an integrated operation of the MSO process which includes process vessel, off-gas system, the salt recycle system, and the ceramic final forms at steady state. The feed rate of organic liquid is assumed at 1.2 liters/hr. The amount of air required for the process including purge air and oxidant air is 861 moles/hr, and the off-gas discharge rate is 904 moles. Assuming continuous salt withdrawal from the MSO system to the salt recycle system, the water required to process the spent salt would be only 0.18 liters/hr. The salt recycle process discharges 0.18 liter/min clean salt brine solution which consists of sodium chloride and sodium fluoride. Metals, metal oxides, and radionuclides are sent to the ceramic final forms system to generate ceramic pellets. As shown in the diagram, 475 grams of ceramic powder is required to stabilize the waste stream from the salt recycle system. As a result, 0.13 liters/hr of ceramic pellets would be generated. For the PCB-contaminated oil, for every 1.2 liters treated, the MSO process would generate 0.18 liters of clean brine solution and 0.13 liters of stabilized ceramic pellets.

9. Results of the Demonstration of the Salt Recycle System

Salt recycle is an important element of the integrated MSO system. It was developed based on extensive small-scale laboratory experiments to prove the concept with subsequent scale-up to the pilot system as part of an integrated MSO facility. The salt recycle process separates metals, mineral residues, and radionuclides from spent salt generated by the MSO process. It includes salt size reduction with a grinder, salt dissolution in water, precipitation, chemical reduction, filtration, pH adjustments, ion exchange, and drying. Each component in the salt recycle system was shown to work as designed.

The salt recycle system has successfully treated six batches of spent salt generated from the MSO vessel in FY 98. For spent salts with high carbonate contents (SR1, SR2, SR3, SR5, SR6), it removed ash, metals, and radionuclides from the salts and returned 95% of the salt for reuse. Table 24 shows the concentrations of cations in the spent salt and clean salt for SR1, SR2, and SR3. These salt consisted of mostly sodium carbonate with traces of sodium chloride, sodium floride, sodium phosphate, sodium sulfate along with some metals such as nickel and chromium. The presence of chromium and nickel in the spent salt was expected because the vessel was made of Inconel 600 which contains chromium and nickel as major components. Table 24 shows that almost all the nickel was removed and more than 90% of chromium in the spent salt was removed in the salt recycle system. It was impossible to remove chromium to less than 20 ppm in the carbonate salt due to the solubility of both Cr+3 and Cr+6 in the salt solution.

SR5 was the spent salt generated from the first treatability specimen (RTS#1) which consisted mostly of methyl chloroform with traces of metals and uranium. SR6 was the spent salt from the second treatability study specimen (RTS#2) which was PCB-contaminated hydraulic oil. Table 25 shows the concentrations of cations and radionuclide (uranium) in the starting spent salts and reusable clean salt for SR5 and SR6. It again shows that almost all the nickel was removed and more than 90% of chromium in the spent salt was removed in the salt recycle system. Uranium concentration in the salt did not change significantly after the salt recycle because uranium forms the tricarbonate uranyl complex ion and stays in the carbonate solution. But if the uranium concentration in the salt solution is significantly higher than 100 ppm, it can be reduced by adding caustic alkali to precipitate out uranium as sodium diuranate [10].

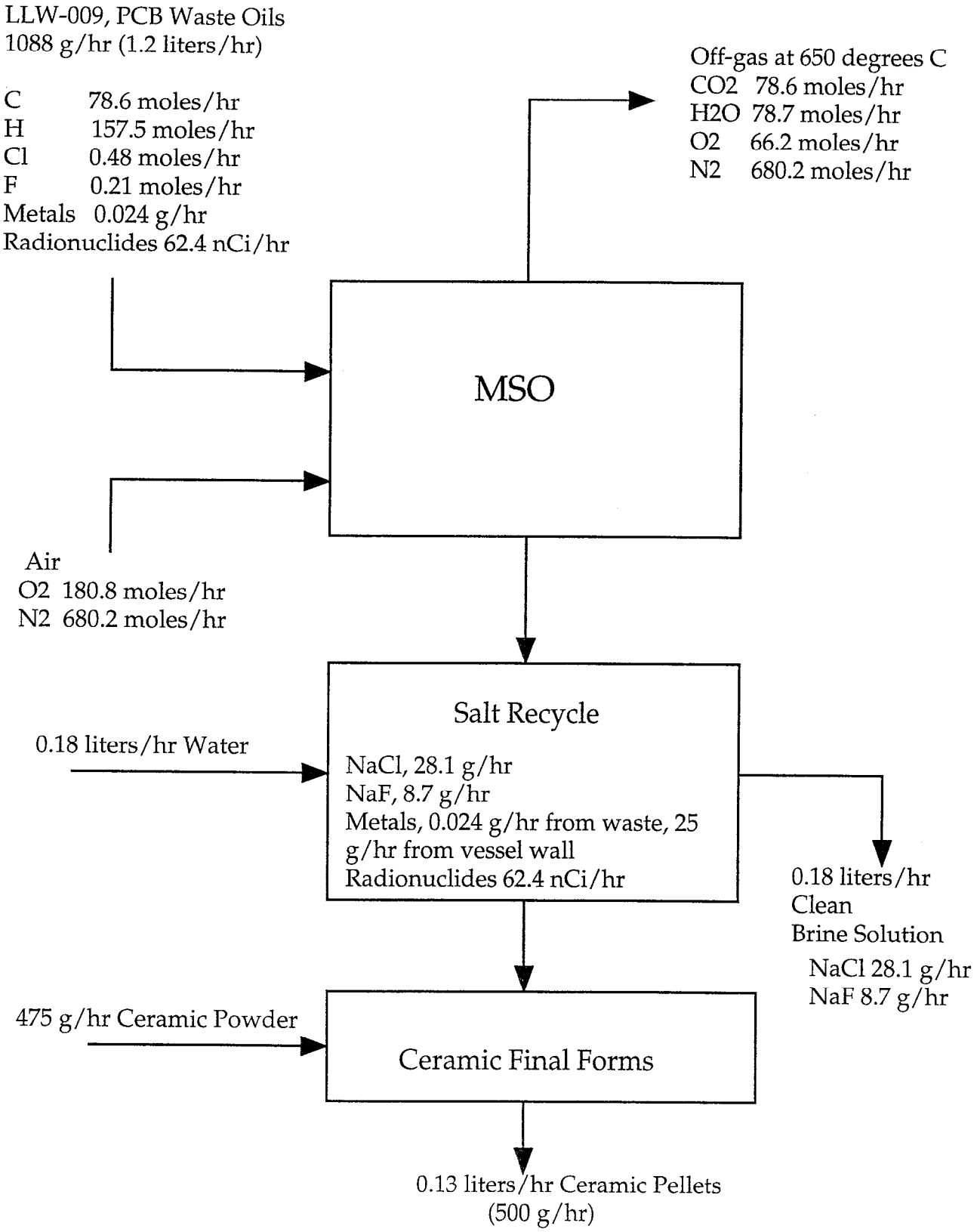


Fig. 13. MSO Flow balance for feed stream LLW-009 (PCB Waste Oils)

Table 24. Cation Compositions of SR1, SR2, SR3 Before and After Salt Recycle (Dry Basis)

	SR1 Before ppm	SR1 After ppm	SR2 Before ppm	SR2 After ppm	SR3 Before ppm	SR3 After ppm
Ag	ND	ND	ND	ND	ND	ND
As	ND	ND	ND	ND	ND	ND
Ba	1	1	37	7.7	2.4	5.7
Be	ND	ND	ND	ND	ND	ND
Cd	3	ND	ND	ND	ND	0.9
Co	2	0.3	5.7	ND	4	0.4
Cr	2900	150	1300	57	500	50
Cu	3	ND	6	ND	2	ND
Mo	16	16	5	7.7	4	5.6
Hg	ND	ND	ND	ND	ND	ND
Ni	53	1	710	1.4	670	1.3
Pb	2	2	20	20	5	2.5
Sb	7	ND	10	7.7	6	2
Se	5	ND	7	ND	ND	ND
Tl	ND	ND	ND	ND	ND	ND
V	ND	ND	3	ND	ND	ND
Zn	ND	ND	220	ND	4	ND

The salt consisted of mostly sodium carbonate with traces of sodium chloride sodium sulfate, and sodium phosphate.

Table 25. Cation Compositions of SR5 and SR6 Before and After Salt Recycle (Dry Basis)				
	SR5	SR5	SR6	SR6
	Before	After	Before	After
	ppm	ppm	ppm	ppm
Ag	ND	ND	ND	ND
As	ND	ND	ND	ND
Ba	1	0.5	8.2	1.1
Be	0.4	ND	ND	ND
Cd	ND	ND	15	ND
Co	0.7	ND	3	ND
Cr	420	32	980	15
Cu	3	ND	7	ND
Mo	1	2	4	2
Hg	ND	ND	ND	ND
Ni	230	ND	840	ND
Pb	ND	ND	10	ND
Sb	ND	ND	ND	ND
Se	ND	ND	ND	ND
Tl	ND	ND	ND	ND
V	ND	ND	ND	ND
Zn	1	ND	66	ND
U	11	9.4	0.63	0.6
The salt consisted of mostly sodium carbonate, some sodium chloride, and traces of sodium sulfate, sodium floride, and Sodium phosphatge.				

For spent salts with low carbonate content (SR4), salt recycle removed ash, metals, and radionuclides from the salts and generated clean brine (sodium chloride) solution which is not considered hazardous. Table 26 shows the cations (excluding sodium and potassium) and radionuclide (uranium) in the starting spent salt and clean salt after the salt recycle. Initial concentrations of Cr, Ni and U in the spent salt were over 100 ppm. Salt recycle successfully reduced Cr, Ni, and U to 0.45 ppm, 2 ppm, and 0.1 ppm, respectively.

Because the chromium concentration in the high carbonate salts (SR1, SR2, SR3, SR5, SR6) did not drop to less than 20 ppm, these salts were not considered for direct disposal. They were reused in the MSO vessel until the chloride contents built up to the level at which the salt could be recycled as "low carbonate," e.g. SR4.

A more comprehensive description of the results of the salt recycle demonstration will be furnished as part of FY99 report.

10. Results of the Ceramic Final Forms Demonstration

No Final Forms demonstrations were done in FY1998, nor were any pellets fabricated from surrogate residues. Equipment functional testing was completed satisfactorily. Practice operations of the batching, milling and calcining were done, using innocuous material.

11. Lessons Learned

A number of lessons were learned in the first years' operation of the MSO processor and offgas system in the Expedited Technology Demonstration (ETD). These lessons and suggestions for improved operation are summarized below:

* Early practice was to allow the salt to freeze with the injector fully immersed in the melt. To prevent plugging in the injector, air flow was maintained through the injector both during freezing and during melting. During one of the melt cycles, the air flow caused the salt to foam up and some passed over into the off-gas pipe. This occurred with salt with a high ash content, and apparently when salt containing certain – as yet undefined - compositions of ash is first melted, its viscosity and surface tension are conducive to foaming. The operational procedure was changed to require the injector be lifted out of the melt every time the salt was allowed to cool.

* The present processor has a salt drainpipe that extends horizontally from the bottom of the processor and drains the hot, molten salt into a pan located beside the processor. At the end of a draining operation, small quantities of salt could wick back into the heater around the drainpipe, thus causing failure of the heater. In addition, relatively small pieces of debris in the salt could plug the pipe. A larger diameter drainpipe pointing down into a drain pan directly under the processor would improve the salt flow and prevent wicking of the salt into the heater. In addition, the processor top cover should be redesigned so that, if necessary, the drainpipe could be cleared while hot with a long rod from the top of the processor. The design must also recognize that the drainpipe and drain pan will likely distort due to temperature cycling. A spare drain pan is thus necessary to support processor operation while salt is being removed from the first pan.

Table 26. Cation Composition in SR4 Salt Before and After Salt Recycle (Dry Basis		
	Starting spent salt	Final clean salt
	(Before) ppm	(After) ppm
Ag	ND	ND
As	ND	ND
Ba	3	1.1
Be	ND	ND
Cd	3	1.5
Co	1	ND
Cr	820	0.45
Cu	1	0.5
Mo	2	2
Hg	ND	ND
Ni	100	2
Pb	7	ND
Sb	10	ND
Se	ND	ND
Tl	ND	ND
V	ND	ND
Zn	2	ND
U	200	0.1
Note: The clean salt consists over 99 wt.% sodium chloride with trace of sodium sulfate.		

* The processor was built with a cooling air blower capable of blowing air underneath the heater assembly, along the vessel wall, to remove excess heat. Since the blower was pushing air into the heater assembly, hot air leaked out through seams and electrical penetrations. On one occasion during activation, this superheated air damaged insulation on the electrical leads to the heaters. The processor also incorporated fins on the outside surface along the lower, melt-containing zone to assist in heat removal. For the feed rates and materials used in the ETD, overheating of the processor never occurred, thus neither the fins nor the cooling air blower proved necessary. However, if forced air cooling is needed in the future, the cooling air blower should be redesigned to pull air through the furnace assembly rather than pushing air through it. The cooling air duct should also include automatic shut-off dampers to prevent heat loss due to free convection when the blower is not being used.

* The injector assembly for injecting the feed material into the molten salt proved to be very robust and was not prone to plugging. However, to simplify the operation and maintenance and possibly to improve efficiency, the following issues should be considered: a) if internal thermocouples are used, they should be replaceable, b) the hoses that feed the injector needed better support with more compact configuration of hose connections at the top of the injector, c) the injector needs a clamping design to hold it in operating position that will tolerate heat and will be easy to operate, and d) the injector should be self-supporting when raised clear of the molten salt.

* The off-gas system design demonstrated that a simple length of bare pipe with its attendant free convection is sufficient to cool the offgas to a temperature that is compatible with the ceramic filter. No active cooling is required. A trap in front of the GSS filter proved very valuable in the ETD. If molten salt is blown (or foams) out of the processor, the trap will prevent damage to the ceramic filter elements. In addition, the only cooling needed after the ceramic filter is the condenser.

* The off-gas system included a steel wire brush in the pipe section exiting the processor to prevent salt plugging of this line. This salt brush proved invaluable. However, the brush could be more "robust" (i.e., better able to unstick itself) and should enter the top of the main processor vessel. If the brush encounters some molten salt at the vessel end of the stroke, it must be able to push this aside or tolerate some salt build up on the wall without getting stuck. The brush is less likely to get stuck or abort its stroke if the system is thoroughly hot when the brush is activated.

* In the present design, the feed system to the reactor could potentially expose the operator to hazardous vapors. The feed station should be in a full fume hood to minimize exposure hazards from the feed material. Additionally, the feed system should be optimized to accept multiple phase liquids and liquids containing suspended particulates without allowing significant phase or particle separation or plugging of the pumps and feed lines.

* In the present design, all of the salt was loaded manually into the reaction vessel using a barrel turner hanging from an overhead hoist. The salt was poured out of a funnel attached to the drum, through a plastic tube and into the processor. This design could potentially cause an exposure risk to the operator. A solids conveyor that eliminates salt handling on top of the processor and conveys the salt in a more automatic and contained fashion should be considered.

For the MSO/ETD Salt Recycle system, lessons and recommendations for improved operation are:

* At present, the entire Salt Recycle system is operated manually. For production use, more automation should be provided. For example, the brine filter should have an easier, perhaps entirely automatic, system for applying the precoat material. The filter should also discharge its filter cake automatically. In addition to filter-related concerns, the valve sequencing for the most common brine transfers should be automated.

* Ground salt is presently conveyed to the dissolution tank using a screw conveyor. Hold-up of salt in this conveyor proved to be excessive, and migration of moisture from the tank into the conveyor caked this remaining salt. A pneumatic type of conveyor would seem to be a better choice since it would have negligible salt hold-up. The conveyor should be isolated from the moist atmosphere in the dissolution tank.

* Significant amounts of non-soluble mineral residue were found in the spent salt. The dissolver tank needs some provision to handle the slurry that results when this salt is introduced. This would include a mixer in the tank plus piping and pumps that can move these solids and pump them into the filter.

* Spray drying of treated brines proved to require expert set-up and operation. Several features of the ETD spray drier should be improved upon for the next-generation system. The wet scrubber should receive more design attention in the following areas: water carry-over from the scrubber into the exhaust piping, and algae growth in the scrubber water.

12. Cost Analysis

Ecology and Environment, Inc. was contracted by the DOE Oakland Operations Office to prepare an innovative technology summary report for the molten salt oxidation project [11]. The report includes a cost analysis for various feeds. The capital cost for a three vessels system with salt recycle and ceramic final forms was estimated at $3.3 M. Without salt recycle and ceramic final form, the capital cost drops to $1.8 M. Unit costs for several feeds are listed in Table 27.

Table 27: Unit Costs for Various Radioactive Feeds Based on 3-Vessel System (in $/kg)

Feeds	MSO [a]	Incineration
Halogenated organic liquid	32	338 [b]
Non-halogenated organic liquid	27	20 [b]
Ion Exchange resins	44	N/A

(a) 3-vessel system, plus operating cost
(b) estimates from LLNL-HWM

13. Conclusion

An integrated MSO pilot-scale facility has been built and demonstrations conducted since December 1997. The facility has been demonstrated with over 20 surrogates and real waste streams. Chlorinated solvents and PCB-contaminated oils, two of the difficult low-level

mixed waste streams at LLNL, were successfully treated in the facility last August with good results. The MSO technology appears ready to be fielded and implemented with a variety of superfund and DOE low-level mixed wastes.

References

1. Martyn Adamson and Peter C. Hsu, "Test Plan for Expedited Technology Demonstration Project,", Rev. 1, Lawrence Livermore National Laboratory, August 1998.

2. Martyn Adamson, Peter C. Hsu, David Hipple, Ken Foster, Robert Hopper, and Tim Ford, "Organic Waste Processing using Molten Salt Oxidation," UCRL-JC-129946, presented at 1998 Euchem Conference on Molten Salt Oxidation, France, June 1998.

3. Peter C. Hsu, David Hipple, Dwight Squire, Erica von Holtz, Robert Hopper, and Martyn Adamson, "Integrated Demonstration of Molten Salt Oxidation with Salt Recycle for Mixed Waste Treatment," UCRL-JC-128143, Proceedings of Waste Management '98, Tucson, AZ, March 1998.

4. Peter C. Hsu, David H. Hipple, and Martyn Adamson, "MSO Salt Recycle System Operation Manual," Lawrence Livermore National Laboratory, 1998.

5. Cesar O. Pruneda, Bruce E. Watkins, and Ravindra S. Upadhye, "Recent Advances in the Molten Salt Destruction of Energetic Materials," URCL-JC-125250, September 1996.

6. Peter C. Hsu and Martyn G. Adamson, "Treatment of Activated Carbon with Molten Salt Oxidation," unpublished report, LLNL, September 1988.

7. J.C. Rudolph, P.A. Hass, J.T. Bell, S.M. Crosley, Cl. Calhoun, Jr., A.H. Gorin, and L.E. Nulf, "Molten Salt Oxidation of Chloro-organic Compounds: Experimental Results for Products Gas Compositions and Final Forms Studies," ORNL/TM-129412, Oak Ridge National Laboratory, April 1995.

8. "Demonstration Testing for Mixed Waste Thermal Treatment Technologies," by Energy and Environmental Research Corporation, available from the website, wastenot.inel.gov/mwfa/ntw/roadmap/compliance/trd/dt.pdt, July 1997.

9. Oscar H. Krikorian, "Selection of Molten Salt Composition for Bench-Scale Molten Salt Processor Tests," UCRL-ID-107081, LLNL, April 1991.

10. Peter C. Hsu, Leslie Summers, Erica von Holtz,David Hipple, Francis Wang, and Martyn Adamson, "Removal of Uranium from MSO Spent Salts," UCRL-126857, Lawrence Livermore National Laboratory, 1998.

11. Denise M Toombs, "Molten Salt Oxidation: Innovative Technology Summary Report," Ecology and Environment, Inc., December 1998.

12. R. A. Van Konynenburg, R. W. Hopper, J. A. Rard, F. J. Ryerson, D. L. Phinney, L. D. Hutcheon & P. G. Curtis, "Ceramic Waste Form for Residues from Molten Salt Oxidation of Mixed Waste," in *Scientific Basis for Nuclear Waste Management XIX,* edited by Dieter Knecht & William M. Murphy (Materials Research Society, Symposium Proceedings 412, Pittsburgh, 1996) pp. 321-328.

13. Operational Safety Procedure 292.19, "ETDP Final Forms System Operation" (effective 12/98).

APPENDIX 1

Prepared for:
Peter C. Hsu
Lawrence Livermore National Laboratory
P.O. Box 808, L-276
Livermore, CA 94551

SOURCE TEST REPORT
Hazardous Waste Emissions Testing
Lawrence Livermore National Laboratories
Molten Salt Oxidation Pilot Plant

Test Date(s): August 18, 19 & 26 1998

Prepared by:

BEST ENVIRONMENTAL Inc.
15890 Foothill Blvd.
San Leandro, CA 94578-2101
Phone (510) 278-4011
Fax (510) 278-4018

TABLE OF CONTENTS

1.0	Test Results Summary	pg.2
2.0	Introduction & General Information	pg.3
3.0	Process Description	pg.4
4.0	Test Program	pg.5
5.0	Test Methods	pg.6
6.0	Test Results	pg.9
7.0	Comments	pg.9
Tabulated Data		pg.11-46
Appendix A- Calculations & Nomenclature		pg.47
Appendix B- Laboratory Reports		pg.69
Appendix C- Field Data Sheets		pg.158
Appendix F- Equipment Calibration Records		pg.187
Appendix E- Process Data		pg.209
Appendix F- Stack Diagram		pg.215
Appendix G- Sampling System Diagrams		pg.219

1.0 Test Results Summary: The average emission rate and destruction efficiency test results for the LLNL Bldg. 292 MSO process test program performed on August 18, 19 & 26, 1998 are presented below:

MSO PROCESS RTS #1 WASTE FEED EMISSIONS SUMMARY TABLE

Test Parameter	MSO Inlet Feed Rate	MSO Outlet Emission Rate	Destruction Efficiency
MCM (1,1,1 trichloroethane)	24.98 g/min	<0.542 ug/min	>99.999998
1,1-dichloroethene	0.41 g/min	1.067 ug/min	99.99974
Tetrachloroethene	0.81 g/min	<0.175 ug/min	>99.999978
Trichloroethene	0.20 g/min	<0.197 ug/min	>99.999980
Trichloro-trifluoroethane	0.57 g/min	<4.372 ug/min	>99.999233
Toluene	14.69 g/min	3.775 ug/min	99.999974
Total PCB	N.A.	N.A.	N.A.
Total Dioxin/Furan	N.A.	56.061 pg/min	N.A.
VOST Volatiles	N.A.	<31.568 ug/min	N.A.
Total MM5 Semi-volatiles	N.A.	<91.376 ug/min	N.A.
Particulate	N.A.	0.00011 lbs/hr	N.A.
Gross Alpha	9,000 pCi/hr	28.55 pCi/hr	N.A.
Gross Beta	14,100 pCi/hr	16.73 pCi/hr	N.A.
Tritium	41,070 pCi/hr	7687.7 pCi/hr	N.A.
HCl	N.A.	<0.0016 g/hr	N.A.

MSO PROCESS RTS #2 WASTE FEED EMISSIONS SUMMARY TABLE

Test Parameter	MSO Inlet Feed Rate	MSO Outlet Emission Rate	Destruction Efficiency
MCM (1,1,1 trichloroethane)	0.168 g/min	<0.291 ug/min	>99.999827
1,1-dichloroethene	0.025 g/min	1.073 ug/min	99.99571
Tetrachloroethene	N.A.	<0.166 ug/min	N.A.
Trichloroethene	N.A.	<0.187 ug/min	N.A.
Trichloro-trifluoroethane	0.213 g/min	<4.151 ug/min	>99.99805
Toluene	2.78 g/min	1.069 ug/min	99.999962
Total PCB	0.0233 g/min	<0.0414 ug/min	>99.99982
Total Dioxin/Furan	N.A.	108.860 pg/min	N.A.
VOST Volatiles	N.A.	<17.820 ug/min	N.A.
Total MM5 Semi-volatiles	N.A.	<95.854 ug/min	N.A.
Particulate	N.A.	0.000034 lbs/hr	N.A.
Gross Alpha	8,140 pCi/hr	15.53 pCi/hr	N.A.
Gross Beta	890 pCi/hr	0.961 pCi/hr	N.A.
Tritium	39,700 pCi/hr	3,564.582 pCi/hr	N.A.
HCl	N.A.	<0.0015 g/hr	N.A.

2.0 Introduction & General Information:

Test Date: August 18, 19 & 26, 1998.

Report Date: November 12, 1998.

Source Facility: Lawrence Livermore National Laboratory (LLNL), Bldg. 292 on Vasco Road in Livermore, California.

Facility Representative: Mr. Peter Hsu, (925) 422-0317.

Subject: Best Environmental Inc. (BEI) was contracted to provide (in-house) emissions testing services on the Molten Salt Oxidation (MSO) pilot plant located at Lawrence Livermore National Laboratory (LLNL), Bldg. 292 on Vasco Road in Livermore, California.

Sampling Locations: Sampling was conducted from the sampling ports located on the 1.375" i.d. inlet and outlet of the GSS (Gas/Solid Separation) filter and from the catalytic converter 4" i.d. outlet stack venting emissions from the MSO process. The sampling ports were located to meet EPA criteria (8 duct diameter downstream and 2 duct diameter upstream from any points of flow disturbance). For more information on the test locations please refer to the Appendix F-Stack Diagrams section in the Appendices.

Sampling Personnel & Test Firm: Regan Best, Dan Cartner, Jeff Mesloh, Phil Romando and Mike Wiley of Best Environmental, Inc., (BEI) 15890 Foothill Blvd., San Leandro, CA, 94578.

Observing Personnel: No representatives from the Bay Area Air Quality Management District (BAAQMD) were notified or present during the test days as the test program was not for compliance purposes. Peter Hsu, David Hipple and Tim Ford of LLNL coordinated operation of the MSO process during testing.

Analytical Laboratories: The following analytical laboratories performed analytical work for this project:

EPA M23 EPA M0030 EPA M0050 EPA M0010	Philip Services Corporation 5555 North Service Road Burlington, Ontario, Canada L7L5H7 Contact: Ron McLeod (905) 332-8788
EPA M114	FGL P.O. Box 272 Santa Paula, CA 93601-0272 Contact: Michel M. Franco (805) 525-3824
EPA M17	BEST ENVIRONMENTAL, INC 15890 Foothill BLVD San Leandro, CA 94578 Contact: Michael Wiley (510) 278-4011

3.0 Process Description: Molten Salt Oxidation (MSO) is a thermal process being demonstrated on a pilot scale for treating low level mixed wastes and energetic materials as an alternative to incineration. The MSO process involves the oxidation and vaporization of organic liquid and solid waste feeds at high temperature in the presence of molten alkali to destroy organic compounds, which produces CO_2 and H_2O vapors while retaining inorganic components such as metals, radionuclides and acid gases in the salt.

The MSO reactor vessel is approximately 9 ft. tall, measuring 11.75" i.d. at the base and 15" i.d. at the top. The vessel is surrounded by an electric furnace and equipped with waste feed, air and carbonate makeup injection lines. Associated activities include operation of the waste feed system, off-gas system, spent salt freeze pan and salt recycle system.

The process begins with the introduction of salt to the reactor and slowly raising the temperature to 950 °C. The air and dispersing gas flows are started and raised to normal operating conditions. The waste feed flow is then started and brought to the desired level. The injector then sprays the liquid and gases into the molten salt where the organics are oxidized and retained in the salt matrix. The off-gasses and any particulate are passed to the gas solid separator filter (GSS), condenser, HEPA filter, and a NOx/CO catalytic converter before being vented to atmosphere outside the building.

For more detail please refer to the process schematics located in the Process Data section of the Appendices.

4.0 Test Program: The source test methods and test locations used for each waste feed test series are summarized below:

RTS #1 WASTE FEED

Test Location	Parameters	Test Method	Runs	Duration
GSS Filter Outlet	Filterable Particulate	EPA Method 17	3	60 min
	Radionuclides	EPA Method 114	3	60 min
	Volatiles (VOST)	EPA Method 0030	9	20 min
	HCl	EPA Method 0050	3	60 min
	DSCFM	EPA Methods 1-4	3	60 min
GSS Filter Inlet	Dioxins/Furans	EPA Method 23	3	180 min
	Semi-Volatiles (MM5)	EPA Method 0010	3	180 min
Catalyst Outlet	Dioxins/Furans	EPA Method 23	1	180 min
	Semi-Volatiles (MM5)	EPA Method 0010	1	180 min
	Volatiles (VOST)	EPA Method 0030	3	20 min
	Radionuclides	EPA Method 114	1	60 min

RTS #2 WASTE FEED

Test Location	Parameters	Test Method	Runs	Duration
GSS Filter Outlet	Filterable Particulate	EPA Method 17	3	60 min
	Radionuclides	EPA Method 114	3	60 min
	Volatiles (VOST)	EPA Method 0030	9	20 min
	HCl	EPA Method 0050	3	60 min
	DSCFM	EPA Methods 1-4	3	60 min
GSS Filter Inlet	Dioxins/Furans, PCB	EPA Method 23	3	180 min
	Semi-Volatiles (MM5)	EPA Method 0010	3	180 min
Catalyst Outlet	Dioxins/Furans, PCB	EPA Method 23	1	180 min
	Semi-Volatiles (MM5)	EPA Method 0010	1	180 min
	Volatiles (VOST)	EPA Method 0030	3	20 min
	Radionuclides	EPA Method 114	1	60 min

5.0 Test Methods: This section is intended to provide an overview of the sampling methods and does not attempt to summarize the sampling procedures that are described in detail in the reference methods.

Volumetric flow rate and moisture determination (EPA Methods 1-4) were performed in conjunction with Methods 5 & 23 to determine mass emissions. Analysis for dioxins/furans, PCB's and semi-volatile compounds were performed on a single combined sample train.

Method 1 is used to determine the duct or stack area and appropriate traverse points that represent equal areas of the duct for sampling and velocity measurements. Sampling at the GSS

inlet and outlet locations were performed at a single point, because of the small duct diameter and the use of a relatively large diameter nozzle.

Method 2 is used to determine stack gas velocity using a standard or S-type pitot tube and inclined manometer. Temperature is monitored using a K-type thermocouple and calibrated Omega temperature meter. Leak checks are performed before and after each traverse to validate the results.

Method 2 QA/QC: Pitot leak checks are performed by pressurizing each leg of the pitot separately to a pressure greater than 3" H_2O. The leak check is passed when no movement in the manometer fluid occurs over 15 seconds. Thermometer calibrations are performed using an Omega Model CL-300 calibrator. Geometric calibrations of S-type pitots are performed every 6-months or following any repairs or modifications, according to guidelines in the CARB QA/QC Volume VI, Table 3. The pitot is visually inspected for damage before each test.

Method 3A is used to determine the molecular weight of the stack gas. Measurements of gas constituents $\%O_2$ and $\%CO_2$ were continuously monitored by facility emission analyzers.

Method 4 is used to determine the moisture content in the gas stream by extracting a sample and condensing the moisture in impingers containing reagents solutions followed by an impinger containing silica gel desiccant. The set-up may vary depending on the primary method it is combined with. e.g., EPA Method 23, 0010, 17. The impingers are immersed in an ice-bath controlled to maintain an outlet sample temperature of less than 68°F. The moisture gained is determined volumetrically and gravimetrically. QA/QC: Results are recorded on the field data sheet. A minimum of 21 cubic feet of sample is pulled using a leak tight pump. Gas sample volume is measured with a calibrated dry gas meter. Sampling system leak checks are performed by capping the nozzle and pulling a vacuum greater than 15 inches of mercury, and observing the meter rate. The leak check is ok if the leak rate is less than 0.02CFM or 4% of the average sample rate, whichever is less. The final leak check is performed at a vacuum at least as high as the highest vacuum pulled during the run. If the final leak check exceeds the criteria, then the volume will be corrected based on the leak rate at the average rate (or vacuum), or the test will be voided, according to the method.

EPA Method 23 is used to determine emissions of Dioxin and Furans. The sampling equipment consists of a heated glass-lined probe with pitot and thermocouples, heated filter box, umbilical connected to a XAD-2 resin trap, a series of four Greenburg-Smith impingers and a meter control module. Front and back half fractions will be analyzed separately using high resolution GC/MS following soxhlet extraction. All resin traps are pre-spiked as part of the method QA/QC. Toluene is used in place of methylene chloride as a recovery solvent. The XAD-2 trap inlet gas temperature will be monitored and recorded every ten minutes by sampling personnel. QA/QC: consists of performing sampling system leak checks before and after each test run. Field blanks and reagent blanks are collected. All the sampling equipment is calibrated. (See method 5). Analytical QA/QC consists of field train blanks, reagent blank, and laboratory blanks, duplicates and spikes.

EPA Method 0010 (Modified Method 5) is used to determine the emissions of semi-volatile (b.p. >100 °C) compounds. The sampling equipment consists of a heat-controlled probe, filter box, an XAD adsorbing resin trap, four Greenburg-Smith impingers, and a meter control module. Isokinetics are maintained by using a programmed HP calculator. All mandatory data is recorded on a BEI data sheet. Organic emissions that pass through the heated filter are adsorbed in the XAD resin. The sample train components are recovered and extracted. The extracts are combined and analyzed using gas chromatography/mass spectrometry (GC/MS) according to EPA Method 8270 procedures (SW-846). Sampling QA/QC: Same as Method 5. Analytical QA/QC consisted of a field train blank, laboratory blanks, duplicates and spikes.

EPA Method 0030 (VOST) is used to determine the emissions of volatile (b.p. <100 °C) compounds. The sampling equipment consists of heat-controlled glass probe, water cooled condenser, a pair of resin traps (tenax & tenax/charcoal), an impinger between the traps to collect liquid condensate. The sampling is non-isokinetic and collects a 20 liter sample at sampling rates of 0.5 to 1 liter per minute depending on the boiling points of the compounds of interest. Three pairs of traps constitute one test run. All mandatory data is recorded on a BEI data sheet. The resin traps are thermally desorbed and analyzed using gas chromatography/mass spectrometry (GC/MS) according to EPA Method 8240 procedures (SW-846). Sampling QA/QC: Same as Method 5. Analytical QA/QC consisted of a field train blank, laboratory blanks, duplicates and spikes.

EPA Method 0050 (~ equivalent to CARB Method 421) is used to determine the emissions of Hydrogen Chloride that pass through the probe/filter assembly maintained at 248±25°F. The sampling equipment consists of heat-controlled probe, filter box (if required), umbilical, four Greenburg-Smith impingers, and a meter control module. Isokinetics (if required) are maintained by using a programmed HP calculator. All mandatory data is recorded on a BEI data sheet. Condensible gaseous emissions that pass through the filter (rated at 99.95% efficient for 0.3μm particles) are collected and recovered from the sample line and back-half of the filter holder. The two impingers (containing a solution of 0.1N sodium hydroxide), the third impinger that is left empty and the forth impinger containing silica gel desiccant. The impinger solution is analyzed using ion chromatography for any of the following; HCl, HNO_3, HBr, HF, H_3PO_4, or H_2SO_4. The impingers are immersed in an ice-bath controlled to maintain an outlet sample temperature of less than 68°F. EPA Method 0050 QA/QC: Same as Method 5.

EPA Method 114 is used to measure radionuclides. Radionuclides differ in the chemical and physical forms, half-lives and type of radiation emitted. No single method for sample collection and analysis is applicable to all types of facilities. For this test program the sample train would be in the Method 5 configuration with the filter analyzed for alpha and beta radionuclides and the condensed water analyzed for tritium. The precise analytical procedure is determined by the laboratory after examination of the sample matrix.

EPA Method 17 is used to determine the filterable particulate emissions. The sampling equipment consists of a stainless steel nozzle, an in-stack 47mm Gelman filter holder with glass fiber filter, followed by a stainless steel, teflon lined probe, Teflon® transfer line and umbilical to four Greenburg-Smith impingers, a pump and a meter control module. The first two impingers each contain 100ml of de-ionized water. A third impinger is left empty and the fourth impinger contains silica gel desiccant to dry the gas before the pump and gas meter.

Filterable particulate is determined gravimetrically from the acetone rinse of the nozzle and the filter housing and the filter. The acetone is evaporated and desiccated in a tared beaker or tin, then it is weighed to 0.01mg. The filter is desiccated and weighed to 0.01mg. The volume gain in the impinger contents and the weight gain in the silica gel are measured and used to determine the moisture content of the gas stream.

Isokinetic sampling is maintained by using a programmed HP calculator and the numbers are calculated and checked following each run. All mandatory data is recorded on a BEST ENVIRONMENTAL, INC (BEI) data sheet. The dry gas meter, pitot, thermocouples, gauges and nozzles are all calibrated every 6 to 12 months as specified in CARB QA/QC Volume VI, Table 3. Nozzles are calibrated to within 0.001" diameter and are inspected for damage prior to each test. Pitot leak checks are performed by pressurizing each leg of the pitot separately to a pressure greater than 3" H_2O. The leak check is passed when no movement in the manometer fluid occurs over 15 seconds. Sampling system leak checks are performed before and after each test run. The sampling system is leak checked by sealing the nozzle, pulling a vacuum greater than 15 inches of mercury, and observing the meter rate. If the leak rate is less than 0.02 CFM or 4% of the average sample rate, whichever is less, the leak check passes. The final leak check is performed at a vacuum at least as high as the highest vacuum pulled during the run.

For sampling system configurations please refer to the diagrams in the Sampling System Diagram section of the appendix of this report.

6.0 Test Results: Tables 1 through 11 on the following pages present the emission results for the MSO process at the GSS inlet, GSS outlet and catalytic converter outlet locations. Results are shown in micrograms or picograms per dry standard cubic meter concentration and ppt, ppb or ppm concentration. Emission rates are shown in picograms or micrograms per minute for ease of comparison with the waste feed rates. Emission rates were calculated from flow rates measured during the Method 23 or Method 17 test periods. Specific compound removal efficiencies were calculated using the waste feed rates as reported by LLNL personnel.

TABULATED DATA

PARAMETER	RTS #1 WASTE FEED	RTS #2 WASTE FEED
Dioxin/Furan	**Table 1**	**Table 2**
PCB	**N.A.**	**Table 3**
Semi-Volatiles	**Table 4**	**Table 5**
Volatiles	**Table 6**	**Table 7**
Particulate/Radionuclide	**Table 8**	**Table 9**
HCl	**Table 10**	**Table 11**

Calculations, laboratory reports, field data sheets, equipment calibrations, process data, stack diagrams and sampling system diagrams are appended to this report. The contents of each appendix section are arranged in the same order as the tabulated data (i.e. laboratory section begins with dioxin/furan lab results and ends with HCl results).

7.0 Comments: The GSS inlet location contained high levels of particulate which clogged the sample filter and made it difficult to maintain perfect isokinetic sampling rates. A single run from each test series was outside the 90%-110% range. This would theoretically bias test results somewhat higher, although results from these runs do not appear to differ from the others.

Acetone and methylene chloride blanks for Method 23 were mistakenly shipped to the analytical laboratory in the same coolers as the VOST tube samples. In the opinion of the laboratory this almost certainly resulted in contamination of the sample tubes with these compounds as the trip blanks are comparable with the sample blanks. The results are shown in the tables but were not included in the summaries.

Results from the triplicate sets of VOST tube pairs for each run were combined to calculate a single result for each compound.

Reporting of average values for triplicate test run series when test results for individual compounds showed both non-detects (<) and detects was decided by majority. That is if two of three test results were non-detect than the average was reported as a non-detect.

With the exception of radionuclides and particulate, test results were not corrected for blank values. California Air Resources Board procedures for toxic emissions calculations generally does not allow blank correction unless the detected compounds are five times greater than the blank values.

The flow measurements at the catalyst outlet were generally higher than at the GSS filter outlet. However these measurements are suspect due to the inherent difficulty in measuring such a low flow in a relatively large duct area.

The details and results contained within this report are to the best of BEI's knowledge an authentic and accurate representation of the test program. If this report is submitted for Compliance purposes it should only be reproduced in its entirety.

If you have any questions concerning this report, or if Best Environmental, Inc. can be of any further assistance, please contact Regan Best, Guy Worthington or Craig Thiry at (510) 278-4011.

Submitted by,

Regan Best
Source Test Manager

Reviewed by,

Guy Worthington
Sr. Project Manager

TABLE 1
RTS #1 Waste Feed
LLNL Bldg. 292 MSO
GSS Inlet & Catalytic Converter Outlet
EPA Method 23 Dioxin / Furan Emission Results

TEST#	1-GSS Inlet	2-GSS Inlet	3-GSS Inlet	AVERAGE	1-Cat. Out
TEST DATE	8/18/98	8/18/98	8/19/98		8/18/98
TEST TIME	1016-1326	1413-1707	0918-1308		1428-1726
SAMPLE VOLUME (DSCF)	104.476	116.462	113.493	**111.477**	151.684
SAMPLE VOLUME (DSCM)	2.959	3.298	3.214	**3.157**	4.296
FLOW RATE (DSCFM)	13.67	13.34	13.32	**13.45**	16.48
STACK GAS TEMP. °F	293	351	318	**320**	
O_2, % vol. dry	12.4	10.0	9.3	**10.6**	
H_2O, % vol	5.1	5.1	4.5	**4.9**	
Total C14-Dibenzofurans (TCDF)					
total pg	34	35	31	**33.3**	49
(pg/dscm)	11.491	10.612	9.645	**10.583**	11.407
(pg/min)	4.449	4.010	3.639	**4.033**	5.325
ppt MW= 304	0.0009	0.0008	0.0008	**0.0008**	0.0009
Total C15-Dibenzofurans (PeCDF)					
total pg	58	68	56	**60.7**	94
(pg/dscm)	19.603	20.617	17.423	**19.214**	21.882
(pg/min)	7.590	7.791	6.573	**7.318**	10.216
ppt MW= 340	0.0014	0.0015	0.0012	**0.0014**	0.0015
Total C16-Dibenzofurans (HxCDF)					
total pg	16	23	20	**19.7**	22
(pg/dscm)	5.408	6.974	6.223	**6.201**	5.121
(pg/min)	2.094	2.635	2.348	**2.359**	2.391
ppt MW= 374	0.0003	0.0004	0.0004	**0.0004**	0.0003
Total C17-Dibenzofurans (HpCDF)					
total pg	<4.2	<6.0	9.2	**<6.5**	<11.0
(pg/dscm)	<1.420	<1.819	2.862	**<2.0337**	<2.561
(pg/min)	<0.550	<0.687	1.080	**<0.772**	<1.195
ppt MW= 408	<0.0001	<0.0001	0.0002	**<0.0001**	<0.0002
C18-Dibenzofurans (OCDF)					
total pg	7.6	9.0	22	**12.9**	<8.9
(pg/dscm)	2.569	2.729	6.845	**4.047**	<2.072
(pg/min)	0.995	1.031	2.582	**1.536**	<0.967
ppt MW= 442	0.0001	0.0001	0.0004	**0.0002**	<0.0001
Total C14-Dibenzo-p-dioxins (TCDD)					
total pg	39	50	34	**41.0**	47
(pg/dscm)	13.181	15.160	10.578	**12.973**	10.941
(pg/min)	5.104	5.728	3.991	**4.941**	5.108
ppt MW= 320	0.0010	0.0011	0.0008	**0.0010**	0.0008

TABLE 1 Continued...

(page 2 of 2)

LLNL Bldg. 292 MSO

GSS Inlet & Catalytic Converter Outlet

Total C15-Dibenzo-p-dioxins (PeCDD)

total pg		14	21	13	**16.0**	27
(pg/dscm)		4.732	6.367	4.045	**5.048**	6.285
(pg/min)		1.832	2.406	1.526	**1.921**	2.934
ppt	MW= 356	0.0003	0.0004	0.0003	**0.0003**	0.0004

Total C16-Dibenzo-p-dioxins (HxCDD)

total pg		<4.1	11	<7.5	**<7.5**	<8.1
(pg/dscm)		<1.386	3.335	<2.333	**<2.351**	<1.886
(pg/min)		<0.537	1.260	<0.880	**<0.892**	<0.880
ppt	MW= 390	<0.0001	0.0002	<0.0001	**<0.0001**	<0.0001

Total C17-Dibenzo-p-dioxins (HpCDD)

total pg		8.2	18	30	**18.7**	10
(pg/dscm)		2.771	5.458	9.334	**5.854**	2.328
(pg/min)		1.073	2.062	3.521	**2.219**	1.087
ppt	MW= 424	0.0002	0.0003	0.0005	**0.0003**	0.0001

C18-Dibenzo-p-dioxins (OCDD)

total pg		22	250	500	**257.3**	97
(pg/dscm)		7.436	75.799	155.564	**79.599**	22.581
(pg/min)		2.879	28.642	58.689	**30.070**	10.542
ppt	MW= 458	0.0004	0.0040	0.0082	**0.0042**	0.0012

Where,

DSCFM = Dry Standard Cubic Feet per Minute

pg/dscm = picograms per dry standard cubic meter

pg/min = Emission rate, picograms per min

ppt = part per trillion

Tstd = Standard Temperature, °F = 68

Calculations,

pg/min = 0.02832 * DSCFM * (pg/dscm)

pg/dscm = total pg/ sample vol, dscm

ppt = pg/dscm * 0.0224 * (Tstd + 460) / 492 / MW

TABLE 2
RTS #2 Waste Feed
LLNL Bldg. 292 MSO
GSS Inlet & Catalytic Converter Outlet
EPA Method 23 Dioxin / Furan Emission Results

TEST#	1-GSS Inlet	2-GSS Inlet	3-GSS Inlet	AVERAGE	1-Cat. Out
TEST DATE	8/26/98	8/26/98	8/26/98		8/26/98
TEST TIME	0903-1216	1309-1616	1636-2002		1210-1510
SAMPLE VOLUME (DSCF)	158.170	126.098	112.188	**132.152**	132.838
SAMPLE VOLUME (DSCM)	4.479	3.571	3.177	**3.743**	3.762
FLOW RATE (DSCFM)	14.45	12.99	13.96	**13.80**	16.27
STACK GAS TEMP. °F	321	341	292	**318**	390
O_2, % vol. dry	10.4	10.0	10.0	**10.1**	
H_2O, % vol	3.2	5.4	5.4	**4.7**	
Total C14-Dibenzofurans (TCDF)					
total pg	390	220	510	**373.3**	14
(pg/dscm)	87.066	61.606	160.521	**103.064**	3.721
(pg/min)	35.629	22.663	63.461	**40.585**	1.715
ppt MW= 304	0.0069	0.0049	0.0127	**0.0081**	0.0003
Total C15-Dibenzofurans (PeCDF)					
total pg	66	120	360	**182.0**	22
(pg/dscm)	14.734	33.603	113.309	**53.882**	5.848
(pg/min)	6.030	12.362	44.796	**21.063**	2.695
ppt MW= 340	0.0010	0.0024	0.0080	**0.0038**	0.0004
Total C16-Dibenzofurans (HxCDF)					
total pg	18	31	79	**42.7**	6
(pg/dscm)	4.018	8.681	24.865	**12.521**	1.515
(pg/min)	1.644	3.193	9.830	**4.889**	0.698
ppt MW= 374	0.0003	0.0006	0.0016	**0.0008**	0.0001
Total C17-Dibenzofurans (HpCDF)					
total pg	6.5	14.0	23.0	**14.5**	<4.2
(pg/dscm)	1.451	3.920	7.239	**4.204**	<1.116
(pg/min)	0.594	1.442	2.862	**1.633**	<0.514
ppt MW= 408	0.0001	0.0002	0.0004	**0.0002**	<0.0001
C18-Dibenzofurans (OCDF)					
total pg	13.0	8.9	9	**10.3**	<7.1
(pg/dscm)	2.902	2.492	2.833	**2.742**	<1.887
(pg/min)	1.188	0.917	1.120	**1.075**	<0.870
ppt MW= 442	0.0002	0.0001	0.0002	**0.0001**	<0.0001
Total C14-Dibenzo-p-dioxins (TCDD)					
total pg	100	94	58	**84.0**	30
(pg/dscm)	22.325	26.322	18.255	**22.301**	7.975
(pg/min)	9.136	9.683	7.217	**8.679**	3.674
ppt MW= 320	0.0017	0.0020	0.0014	**0.0017**	0.0006

TABLE 2 Continued...

(page 2 of 2)

RTS #2 Waste Feed
LLNL Bldg. 292 MSO
GSS Inlet & Catalytic Converter Outlet
EPA Method 23 Dioxin / Furan Emission Results

Total C15-Dibenzo-p-dioxins (PeCDD)

total pg		24	34	15	**24.3**	8
(pg/dscm)		5.358	9.521	4.721	**6.533**	1.994
(pg/min)		2.193	3.503	1.867	**2.521**	0.919
ppt	MW= 356	0.0004	0.0006	0.0003	**0.0004**	0.0001

Total C16-Dibenzo-p-dioxins (HxCDD)

total pg		9	20	10	**13**	<4.0
(pg/dscm)		2.032	5.601	3.147	**3.593**	<1.063
(pg/min)		0.831	2.060	1.244	**1.379**	<0.490
ppt	MW= 390	0.0001	0.0003	0.0002	**0.0002**	<0.0001

Total C17-Dibenzo-p-dioxins (HpCDD)

total pg		12	26	13	**17.0**	<4.4
(pg/dscm)		2.679	7.281	4.092	**4.684**	<1.170
(pg/min)		1.096	2.678	1.618	**1.797**	<0.539
ppt	MW= 424	0.0002	0.0004	0.0002	**0.0003**	<0.0001

C18-Dibenzo-p-dioxins (OCDD)

total pg		290	200	230	**240.0**	9
(pg/dscm)		64.741	56.005	72.392	**64.379**	2.392
(pg/min)		26.494	20.603	28.620	**25.239**	1.102
ppt	MW= 458	0.0034	0.0029	0.0038	**0.0034**	0.0001

Where,

DSCFM = Dry Standard Cubic Feet per Minute

pg/dscm = picograms per dry standard cubic meter

pg/min = Emission rate, picograms per min

ppt = part per trillion

Tstd = Standard Temperature, °F = 68

Calculations,

pg/min = 0.02832 * DSCFM * (pg/dscm)

pg/dscm = total pg/ sample vol, dscm

ppt = pg/dscm * 0.0224 * (Tstd + 460) / 492 / MW

TABLE 3
RTS #2 Waste Feed
LLNL Bldg. 292 MSO
GSS Inlet & Catalytic Converter Outlet
EPA Method 23 PCB Emission Results

TEST#	1-GSS Inlet	2-GSS Inlet	3-GSS Inlet	AVERAGE	1-Cat. Out
TEST DATE	8/26/98	8/26/98	8/26/98		8/26/98
TEST TIME	0903-1216	1309-1616	1636-2002		1210-1510
SAMPLE VOLUME (DSCF)	158.170	126.098	112.188	**132.152**	132.838
SAMPLE VOLUME (DSCM)	4.479	3.571	3.177	**3.743**	3.762
FLOW RATE (DSCFM)	14.45	12.99	13.96	**13.80**	16.27
STACK GAS TEMP. °F	321	341	292	**318**	390
O_2, % vol. dry	10.4	10.0	10.0	**10.1**	
H_2O, % vol	3.2	5.4	5.4	**4.7**	
Chlorobiphenyls ($C_{12}H_9Cl$)					
total ug	<0.073	<0.040	<0.021	**<0.045**	<0.017
(µg/dscm)	<0.0163	<0.0112	<0.0066	**<0.0114**	<0.0045
(µg/min)	<0.0067	<0.0041	<0.0026	**<0.0045**	<0.0021
ppb MW= 188.7	<0.0021	<0.0014	<0.0008	**<0.0014**	<0.0006
Dichlorobiphenyls ($C_{12}H_8Cl_2$)					
total ug	<0.130	<0.088	<0.019	**<0.079**	<0.015
(µg/dscm)	<0.0290	<0.0246	<0.0060	**<0.0199**	<0.0040
(µg/min)	<0.0119	<0.0091	<0.0024	**<0.0078**	<0.0018
ppb MW= 223.1	<0.0031	<0.0027	<0.0006	**<0.0021**	<0.0004
Trichlorobiphenyls ($C_{12}H_7Cl_3$)					
total ug	0.230	<0.016	<0.030	**<0.092**	<0.018
(µg/dscm)	0.0513	<0.0045	<0.0094	**<0.0218**	<0.0048
(µg/min)	0.0210	<0.0016	<0.0037	**<0.0088**	<0.0022
ppb MW= 257.6	0.0048	<0.0004	<0.0009	**<0.0020**	<0.0004
Tetrachlorobiphenyls ($C_{12}H_6Cl_4$)					
total ug	0.760	<0.053	<0.035	**<0.283**	<0.054
(µg/dscm)	0.1697	<0.0148	<0.0110	**<0.0652**	<0.0144
(µg/min)	0.0694	<0.0055	<0.0044	**<0.0264**	<0.0066
ppb MW= 292.0	0.0140	<0.0012	<0.0009	**<0.0054**	<0.0012
Pentachlorobiphenyls ($C_{12}H_5Cl_5$)					
total ug	0.230	<0.034	<0.031	**<0.098**	<0.028
(µg/dscm)	0.0513	<0.0095	<0.0098	**<0.0235**	<0.0074
(µg/min)	0.0210	<0.0035	<0.0039	**<0.0095**	<0.0034
ppb MW= 326.4	0.0038	<0.0007	<0.0007	**<0.0017**	<0.0005
Hexachlorobiphenyls ($C_{12}H_4Cl_6$)					
total ug	<0.038	0.030	<0.031	**<0.033**	<0.021
(µg/dscm)	<0.0085	0.0084	<0.0098	**<0.0089**	<0.0056
(µg/min)	<0.0035	0.0031	<0.0039	**<0.0035**	<0.0026
ppb MW= 360.9	<0.0006	0.0006	<0.0006	**<0.0006**	<0.0004

TABLE 3 Continued... (page 2 of 2)
RTS #2 Waste Feed
LLNL Bldg. 292 MSO
GSS Inlet & Catalytic Converter Outlet
EPA Method 23 PCB Emission Results

Heptachlorobiphenyls ($C_{12}H_3Cl_7$)

total ug	<0.034	<0.017	<0.035	**<0.029**	<0.018
(µg/dscm)	<0.0076	<0.0048	<0.0110	**<0.0078**	<0.0048
(µg/min)	<0.0031	<0.0018	<0.0044	**<0.0031**	<0.0022
ppb MW= 395.3	<0.0005	<0.0003	<0.0007	**<0.0005**	<0.0003

Octachlorobiphenyls ($C_{12}H_2Cl_8$)

total ug	<0.048	<0.110	<0.043	**<0.067**	<0.066
(µg/dscm)	<0.0107	<0.0308	<0.0135	**<0.0184**	<0.0175
(µg/min)	<0.0044	<0.0113	<0.0054	**<0.0070**	<0.0081
ppb MW= 429.8	<0.0006	<0.0017	<0.0008	**<0.0010**	<0.0010

Nonachlorobiphenyls ($C_{12}HCl_9$)

total ug	<0.018	<0.038	<0.021	**<0.026**	<0.027
(µg/dscm)	<0.0040	<0.0106	<0.0066	**<0.0071**	<0.0072
(µg/min)	<0.0016	<0.0039	<0.0026	**<0.0027**	<0.0033
ppb MW= 464.2	<0.0002	<0.0006	<0.0003	**<0.0004**	<0.0004

Decachlorobiphenyls ($C_{12}Cl_{10}$)

total ug	<0.022	<0.022	<0.021	**<0.022**	<0.023
(µg/dscm)	<0.0049	<0.0062	<0.0066	**<0.0059**	<0.0061
(µg/min)	<0.0020	<0.0023	<0.0026	**<0.0023**	<0.0028
ppb MW= 498.7	<0.0002	<0.0003	<0.0003	**<0.0003**	<0.0003

Total PCB's

total ug	1.20	0.12	<0.019	**0.446**	<0.015
(µg/dscm)	0.2679	0.0336	<0.0060	**0.1025**	<0.0040
(µg/min)	0.1096	0.0124	<0.0024	**0.0414**	<0.0018

Where,

DSCFM = Dry Standard Cubic Feet per Minute

µg/dscm = micrograms per dry standard cubic meter

µg/min = Emission rate, micrograms per minute

ppb = part per billion

Tstd = Standard Temperature, °F 68

Calculations,

µg/min = 0.02832 * DSCFM * (µg/dscm)

µg/dscm = total µg/ sample vol, dscm

ppb = µg/dscm * 22.4 * (Tstd + 460) / 492 / MW

TABLE 4
RTS #1 WASTE FEED
LLNL Bldg. 292 MSO
GSS Inlet & Catalytic Converter Outlet
EPA Test Method 0010 - Modified Method 5

TEST#	1-GSS Inlet	2-GSS Inlet	3-GSS Inlet	AVERAGE	1-Cat. Out
TEST DATE	8/18/98	8/18/98	8/19/98		8/18/98
TEST TIME	1016-1326	1413-1707	0918-1308		1428-1726
SAMPLE VOLUME (DSCF)	104.476	116.462	113.493	**111.477**	151.684
SAMPLE VOLUME (DSCM)	2.959	3.298	3.214	**3.157**	4.296
FLOW RATE (DSCFM)	13.67	13.34	13.32	**13.45**	16.48
STACK GAS TEMP. °F	292.5	351.0	317.9	**320.5**	
O_2, % vol. dry	12.4	10.0	9.3	**10.6**	
H_2O, % vol	5.1	5.1	4.5	**4.9**	
Aniline					
total ug	<40	<40	<40	**<40**	<40
(ug / dscm)	<13.519	<12.128	<12.445	**<12.697**	<9.311
(ug / min)	<5.234	<4.583	<4.695	**<4.837**	<4.346
ppb MW 93.0	<3.494	<3.135	<3.217	**<3.282**	<2.407
Phenol					
total ug	<4.5	<1.2	<1.2	**<2.3**	<1.2
(ug / dscm)	<1.521	<0.364	<0.373	**<0.753**	<0.279
(ug / min)	<0.589	<0.137	<0.141	**<0.289**	<0.130
ppb MW 94.0	<0.389	<0.093	<0.095	**<0.192**	<0.071
Bis(2-chloroethyl)ether					
total ug	<3.2	<3.2	<3.2	**<3.2**	<3.2
(ug / dscm)	<1.082	<0.970	<0.996	**<1.016**	<0.745
(ug / min)	<0.419	<0.367	<0.376	**<0.387**	<0.348
ppb MW 143.0	<0.182	<0.163	<0.167	**<0.171**	<0.125
2-Chlorophenol					
total ug	<2.0	<2.0	<2.0	**<2.0**	<2.0
(ug / dscm)	<0.676	<0.606	<0.622	**<0.635**	<0.466
(ug / min)	<0.262	<0.229	<0.235	**<0.242**	<0.217
ppb MW 128.6	<0.126	<0.113	<0.116	**<0.119**	<0.087
1,3-Dichlorobenzene					
total ug	<6.0	<6.0	<6.0	**<6.0**	<6.0
(ug / dscm)	<2.028	<1.819	<1.867	**<1.905**	<1.397
(ug / min)	<0.785	<0.687	<0.704	**<0.726**	<0.652
ppb MW 147.0	<0.332	<0.297	<0.305	**<0.311**	<0.228

TABLE 4 Continued...

(page 2 of 9)

RTS #1 WASTE FEED

EPA Test Method 0010 - Modified Method 5

1-4-Dichlorobenzene

total ug		<6.0	<6.0	<6.0	**<6.0**	<6.0
(ug / dscm)		<2.028	<1.819	<1.867	**<1.905**	<1.397
(ug / min)		<0.785	<0.687	<0.704	**<0.726**	<0.652
ppb	MW 147.0	<0.332	<0.297	<0.305	**<0.311**	<0.228

1,2-Dichlorobenzene

total ug		<6.8	<6.8	<6.8	**<6.8**	<6.8
(ug / dscm)		<2.298	<2.062	<2.116	**<2.159**	<1.583
(ug / min)		<0.890	<0.779	<0.798	**<0.822**	<0.739
ppb	MW 147.0	<0.376	<0.337	<0.346	**<0.353**	<0.259

2-Methylphenol

total ug		<4.8	<4.8	<4.8	**<4.8**	<4.8
(ug / dscm)		<1.622	<1.455	<1.493	**<1.524**	<1.117
(ug / min)		<0.628	<0.550	<0.563	**<0.580**	<0.521
ppb	MW 104.1	<0.375	<0.336	<0.345	**<0.352**	<0.258

Bis(2-chloroisopropyl)ether

total ug		<4.4	<4.4	<4.4	**<4.4**	<4.4
(ug / dscm)		<1.487	<1.334	<1.369	**<1.397**	<1.024
(ug / min)		<0.576	<0.504	<0.516	**<0.532**	<0.478
ppb	MW 132.1	<0.271	<0.243	<0.249	**<0.254**	<0.186

4-Methylphenol

total ug		<6.4	<6.4	<6.4	**<6.4**	<6.4
(ug / dscm)		<2.163	<1.940	<1.991	**<2.032**	<1.490
(ug / min)		<0.838	<0.733	<0.751	**<0.774**	<0.695
ppb	MW 104.1	<0.500	<0.448	<0.460	**<0.469**	<0.344

N-Nitroso-di-N-Propylamine

total ug		<4.4	<4.4	<4.4	**<4.4**	<4.4
(ug / dscm)		<1.487	<1.334	<1.369	**<1.397**	<1.024
(ug / min)		<0.576	<0.504	<0.516	**<0.532**	<0.478
ppb	MW 130.0	<0.275	<0.247	<0.253	**<0.258**	<0.189

Hexachloroethane

total ug		<4.4	<4.4	<4.4	**<4.4**	<4.4
(ug / dscm)		<1.487	<1.334	<1.369	**<1.397**	<1.024
(ug / min)		<0.576	<0.504	<0.516	**<0.532**	<0.478
ppb	MW 236.7	<0.151	<0.135	<0.139	**<0.142**	<0.104

Nitrobenzene

total ug		<3.2	<3.2	<3.2	**<3.2**	<3.2
(ug / dscm)		<1.082	<0.970	<0.996	**<1.016**	<0.745
(ug / min)		<0.419	<0.367	<0.376	**<0.387**	<0.348
ppb	MW 123.1	<0.211	<0.189	<0.194	**<0.198**	<0.145

TABLE 4 Continued...

(page 3 of 9)

RTS #1 WASTE FEED

EPA Test Method 0010 - Modified Method 5

Isophorone

total ug		<4.0	<4.0	<4.0	**<4.0**	<4.0
(ug / dscm)		<1.352	<1.213	<1.245	**<1.270**	<0.931
(ug / min)		<0.523	<0.458	<0.470	**<0.484**	<0.435
ppb	MW 138.2	<0.235	<0.211	<0.216	**<0.221**	<0.162

2-Nitrophenol

total ug		<4.8	<4.8	<4.8	**<4.8**	9.7
(ug / dscm)		<1.622	<1.455	<1.493	**<1.524**	2.258
(ug / min)		<0.628	<0.550	<0.563	**<0.580**	<1.054
ppb	MW 139.1	<0.280	<0.252	<0.258	**<0.263**	0.390

2,4-Dimethylphenol

total ug		<40.0	<40.0	<40.0	**<40.0**	<40.0
(ug / dscm)		<13.519	<12.128	<12.445	**<12.697**	<9.311
(ug / min)		<5.234	<4.583	<4.695	**<4.837**	<4.346
ppb	MW 122.2	<2.659	<2.386	<2.448	**<2.498**	<1.832

Bis(2-chloroethoxy)methane

total ug		<4.8	<4.8	<4.8	**<4.8**	<4.8
(ug / dscm)		<1.622	<1.455	<1.493	**<1.524**	<1.117
(ug / min)		<0.628	<0.550	<0.563	**<0.580**	<0.521
ppb	MW 173.0	<0.225	<0.202	<0.208	**<0.212**	<0.155

2,4-Dichlorophenol

total ug		<4.8	<4.8	<4.8	**<4.8**	<4.8
(ug / dscm)		<1.622	<1.455	<1.493	**<1.524**	<1.117
(ug / min)		<0.628	<0.550	<0.563	**<0.580**	<0.521
ppb	MW 163.0	<0.239	<0.215	<0.220	**<0.225**	<0.165

1,2,4-Trichlorobenzene

total ug		<8.8	<8.8	<8.8	**<8.8**	<8.8
(ug / dscm)		<2.974	<2.668	<2.738	**<2.793**	<2.048
(ug / min)		<1.152	<1.008	<1.033	**<1.064**	<0.956
ppb	MW 181.5	<0.394	<0.353	<0.363	**<0.370**	<0.271

Napthalene

total ug		<7.6	<7.6	<7.6	**<7.6**	<7.6
(ug / dscm)		<2.569	<2.304	<2.365	**<2.413**	<1.769
(ug / min)		<0.995	<0.871	<0.892	**<0.919**	<0.826
ppb	MW 128.0	<0.482	<0.433	<0.444	**<0.453**	<0.332

4-Chloroaniline

total ug		<40.0	<40.0	<40.0	**<40.0**	<40.0
(ug / dscm)		<13.519	<12.128	<12.445	**<12.697**	<9.311
(ug / min)		<5.234	<4.583	<4.695	**<4.837**	<4.346
ppb	MW 127.6	<2.547	<2.285	<2.345	**<2.392**	<1.754

TABLE 4 Continued...
(page 4 of 9)
RTS #1 WASTE FEED
EPA Test Method 0010 - Modified Method 5

Hexachlorobutadiene

total ug		<4.0	<4.0	<4.0	**<4.0**	<4.0
(ug / dscm)		<1.352	<1.213	<1.245	**<1.270**	<0.931
(ug / min)		<0.523	<0.458	<0.470	**<0.484**	<0.435
ppb	MW 260.8	<0.125	<0.112	<0.115	**<0.117**	<0.086

4-Chloro-3-Methylphenol

total ug		<5.6	<5.6	<5.6	**<5.6**	<5.6
(ug / dscm)		<1.893	<1.698	<1.742	**<1.778**	<1.304
(ug / min)		<0.733	<0.642	<0.657	**<0.677**	<0.608
ppb	MW 142.6	<0.319	<0.286	<0.294	**<0.300**	<0.220

2-Methylnaphthalene

total ug		<7.2	<7.2	<7.2	**<7.2**	<7.2
(ug / dscm)		<2.433	<2.183	<2.240	**<2.286**	<1.676
(ug / min)		<0.942	<0.825	<0.845	**<0.871**	<0.782
ppb	MW 142.0	<0.412	<0.370	<0.379	**<0.387**	<0.284

Hexachlorocyclopentadiene

total ug		<40.0	<40.0	<40.0	**<40.0**	<40.0
(ug / dscm)		<13.519	<12.128	<12.445	**<12.697**	<9.311
(ug / min)		<5.234	<4.583	<4.695	**<4.837**	<4.346
ppb	MW 272.8	<1.191	<1.069	<1.097	**<1.119**	<0.820

2,4,6-Trichlorophenol

total ug		<4.8	<4.8	<4.8	**<4.8**	<4.8
(ug / dscm)		<1.622	<1.455	<1.493	**<1.524**	<1.117
(ug / min)		<0.628	<0.550	<0.563	**<0.580**	<0.521
ppb	MW 197.5	<0.197	<0.177	<0.182	**<0.185**	<0.136

2,4,5-Trichlorophenol

total ug		<6.8	<6.8	<6.8	**<6.8**	<6.8
(ug / dscm)		<2.298	<2.062	<2.116	**<2.159**	<1.583
(ug / min)		<0.890	<0.779	<0.798	**<0.822**	<0.739
ppb	MW 197.5	<0.280	<0.251	<0.258	**<0.263**	<0.193

2-Chloronaphthalene

total ug		<8.8	<8.8	<8.8	**<8.8**	<8.8
(ug / dscm)		<2.974	<2.668	<2.738	**<2.793**	<2.048
(ug / min)		<1.152	<1.008	<1.033	**<1.064**	<0.956
ppb	MW 162.6	<0.440	<0.394	<0.405	**<0.413**	<0.303

2-Nitroaniline

total ug		<40.0	<40.0	<40.0	**<40.0**	<40.0
(ug / dscm)		<13.519	<12.128	<12.445	**<12.697**	<9.311
(ug / min)		<5.234	<4.583	<4.695	**<4.837**	<4.346
ppb	MW 138.1	<2.353	<2.111	<2.166	**<2.210**	<1.621

TABLE 4 Continued...
(page 5 of 9)
RTS #1 WASTE FEED
EPA Test Method 0010 - Modified Method 5

Dimethylphthalate

total ug		<2.8	<2.8	<2.8	**<2.8**	<2.8
(ug / dscm)		<0.946	<0.849	<0.871	**<0.889**	<0.652
(ug / min)		<0.366	<0.321	<0.329	**<0.339**	<0.304
ppb	MW 194.2	<0.117	<0.105	<0.108	**<0.110**	<0.081

Acenaphthylene

total ug		<6.4	<6.4	<6.4	**<6.4**	<6.4
(ug / dscm)		<2.163	<1.940	<1.991	**<2.032**	<1.490
(ug / min)		<0.838	<0.733	<0.751	**<0.774**	<0.695
ppb	MW 152.0	<0.342	<0.307	<0.315	**<0.321**	<0.236

2,6-Dinitrotoluene

total ug		<4.0	<4.0	<4.0	**<4.0**	<4.0
(ug / dscm)		<1.352	<1.213	<1.245	**<1.270**	<0.931
(ug / min)		<0.523	<0.458	<0.470	**<0.484**	<0.435
ppb	MW 182.1	<0.178	<0.160	<0.164	**<0.168**	<0.123

3-Nitroaniline

total ug		<40.0	<40.0	<40.0	**<40.0**	<40.0
(ug / dscm)		<13.519	<12.128	<12.445	**<12.697**	<9.311
(ug / min)		<5.234	<4.583	<4.695	**<4.837**	<4.346
ppb	MW 138.1	<2.353	<2.111	<2.166	**<2.210**	<1.621

Acenaphthene

total ug		<8.0	<8.0	<8.0	**<8.0**	<8.0
(ug / dscm)		<2.704	<2.426	<2.489	**<2.539**	<1.862
(ug / min)		<1.047	<0.917	<0.939	**<0.967**	<0.869
ppb	MW 154.0	<0.422	<0.379	<0.389	**<0.396**	<0.291

2,4-Dinitrophenol

total ug		<40.0	<40.0	<40.0	**<40.0**	<40.0
(ug / dscm)		<13.519	<12.128	<12.445	**<12.697**	<9.311
(ug / min)		<5.234	<4.583	<4.695	**<4.837**	<4.346
ppb	MW 184.1	<1.765	<1.584	<1.625	**<1.658**	<1.216

4-Nitrophenol

total ug		<40.0	<40.0	<40.0	**<40.0**	<40.0
(ug / dscm)		<13.519	<12.128	<12.445	**<12.697**	<9.311
(ug / min)		<5.234	<4.583	<4.695	**<4.837**	<4.346
ppb	MW 139.1	<2.336	<2.096	<2.151	**<2.194**	<1.609

Dibenzofuran

total ug		<40.0	<40.0	<40.0	<40.0	<40.0
(ug / dscm)		<13.519	<12.128	<12.445	**<12.697**	<9.311
(ug / min)		<5.234	<4.583	<4.695	**<4.837**	<4.346
ppb	MW 168.2	<1.932	<1.733	<1.779	**<1.815**	<1.331

TABLE 4 Continued...
(page 6 of 9)
RTS #1 WASTE FEED
EPA Test Method 0010 - Modified Method 5

2,4-Dinitrotoluene

total ug		<4.4	<4.4	<4.4	**<4.4**	<4.4
(ug / dscm)		<1.487	<1.334	<1.369	**<1.397**	<1.024
(ug / min)		<0.576	<0.504	<0.516	**<0.532**	<0.478
ppb	MW 182.1	<0.196	<0.176	<0.181	**<0.184**	<0.135

Diethyl phthalate

total ug		9.9	13	3.1	**8.667**	<1.6
(ug / dscm)		3.346	3.942	0.964	**2.751**	<0.372
(ug / min)		1.296	1.489	0.364	**1.050**	0.174
ppb	MW 222.2	0.362	0.426	0.104	**0.298**	<0.040

4-Chlorophenylphenylether

total ug		<7.2	<7.2	<7.2	**<7.2**	<7.2
(ug / dscm)		<2.433	<2.183	<2.240	**<2.286**	<1.676
(ug / min)		<0.942	<0.825	<0.845	**<0.871**	<0.782
ppb	MW 204.7	<0.286	<0.256	<0.263	**<0.268**	<0.197

Fluorene

total ug		<5.2	<5.2	<5.2	**<5.2**	<5.2
(ug / dscm)		<1.757	<1.577	<1.618	**<1.651**	<1.210
(ug / min)		<0.680	<0.596	<0.610	**<0.629**	<0.565
ppb	MW 166.0	<0.255	<0.228	<0.234	**<0.239**	<0.175

4-Nitroaniline

total ug		<40.0	<40.0	<40.0	**<40.0**	<40.0
(ug / dscm)		<13.519	<12.128	<12.445	**<12.697**	<9.311
(ug / min)		<5.234	<4.583	<4.695	**<4.837**	<4.346
ppb	MW 138.1	<2.353	<2.111	<2.166	**<2.210**	<1.621

4,6-Dintro-2-methylphenol

total ug		<4.8	<4.8	<4.8	**<4.8**	<4.8
(ug / dscm)		<1.622	<1.455	<1.493	**<1.524**	<1.117
(ug / min)		<0.628	<0.550	<0.563	**<0.580**	<0.521
ppb	MW 198.1	<0.197	<0.177	<0.181	**<0.185**	<0.136

N-Nitrosodiphenylamine

total ug		<14.0	<14.0	<14.0	**<14.0**	<14.0
(ug / dscm)		<4.732	<4.245	<4.356	**<4.444**	<3.259
(ug / min)		<1.832	<1.604	<1.643	**<1.693**	<1.521
ppb	MW 198.2	<0.574	<0.515	<0.528	**<0.539**	<0.395

4-Bromophenylphenylether

total ug		<6.4	<6.4	<6.4	**<6.4**	<6.4
(ug / dscm)		<2.163	<1.940	<1.991	**<2.032**	<1.490
(ug / min)		<0.838	<0.733	<0.751	**<0.774**	<0.695
ppb	MW 221.5	<0.235	<0.211	<0.216	**<0.220**	<0.162

TABLE 4 Continued...

(page 7 of 9)

RTS #1 WASTE FEED

EPA Test Method 0010 - Modified Method 5

Hexachlorobenzene

total ug		<4.0	<4.0	<4.0	**<4.0**	<4.0
(ug / dscm)		<1.352	<1.213	<1.245	**<1.270**	<0.931
(ug / min)		<0.523	<0.458	<0.470	**<0.484**	<0.435
ppb	MW 284.8	<0.114	<0.102	<0.105	**<0.107**	<0.079

Pentachlorophenol

total ug		<6.0	<6.0	<6.0	**<6.0**	<6.0
(ug / dscm)		<2.028	<1.819	<1.867	**<1.905**	<1.397
(ug / min)		<0.785	<0.687	<0.704	**<0.726**	<0.652
ppb	MW 266.3	<0.183	<0.164	<0.169	**<0.172**	<0.126

Phenanthrene

total ug		19	3.7	4.0	**8.9**	<2.4
(ug / dscm)		6.422	1.122	1.245	**2.929**	<0.559
(ug / min)		2.486	0.424	0.470	**1.127**	0.261
ppb	MW 176.0	0.877	0.153	0.170	**0.400**	<0.076

Anthracene

total ug		<4.4	<4.4	<4.4	**<4.4**	<4.4
(ug / dscm)		<1.487	<1.334	<1.369	**<1.397**	<1.024
(ug / min)		<0.576	<0.504	<0.516	**<0.532**	<0.478
ppb	MW 176.0	<0.203	<0.182	<0.187	**<0.191**	<0.140

Carbazole

total ug		<1.2	<1.2	<1.2	**<1.2**	<1.2
(ug / dscm)		<0.406	<0.364	<0.373	**<0.381**	<0.279
(ug / min)		<0.157	<0.137	<0.141	**<0.145**	<0.130
ppb	MW 167.0	<0.058	<0.052	<0.054	**<0.055**	<0.040

Di-n-butyl phthalate

total ug		31	21	9.8	**20.6**	<4.0
(ug / dscm)		10.477	6.367	3.049	**6.631**	<0.931
(ug / min)		4.057	2.406	1.150	**2.538**	0.435
ppb	MW 278.4	0.905	0.550	0.263	**0.573**	<0.080

Fluoranthene

total ug		16	<4.0	<4.0	**<8.0**	<4.0
(ug / dscm)		5.408	<1.213	<1.245	**<2.622**	<0.931
(ug / min)		2.094	<0.458	<0.470	**<1.007**	<0.435
ppb	MW 202.0	0.644	<0.144	<0.148	**<0.312**	<0.111

Pyrene

total ug		9.3	<2.0	<2.0	**<4.4**	<2.0
(ug / dscm)		3.143	<0.606	<0.622	**<1.457**	<0.466
(ug / min)		1.217	<0.229	<0.235	**<0.560**	<0.217
ppb	MW 202.0	0.374	<0.072	<0.074	**<0.173**	<0.055

TABLE 4 Continued...
(page 8 of 9)
RTS #1 WASTE FEED
EPA Test Method 0010 - Modified Method 5

Benzyl butyl phthalate

total ug		<5.2	<5.2	<5.2	**<5.2**	<5.2
(ug / dscm)		<1.757	<1.577	<1.618	**<1.651**	<1.210
(ug / min)		<0.680	<0.596	<0.610	**<0.629**	<0.565
ppb	MW 312.4	<0.135	<0.121	<0.124	**<0.127**	<0.093

3,3-Dichlorobenzidine

total ug		<40.0	<40.0	<40.0	**<40.0**	<40.0
(ug / dscm)		<13.519	<12.128	<12.445	**<12.697**	<9.311
(ug / min)		<5.234	<4.583	<4.695	**<4.837**	<4.346
ppb	MW 253.1	<1.284	<1.152	<1.182	**<1.206**	<0.884

Benzo(a)anthracene

total ug		<3.2	<3.2	<3.2	**<3.2**	<3.2
(ug / dscm)		<1.082	<0.970	<0.996	**<1.016**	<0.745
(ug / min)		<0.419	<0.367	<0.376	**<0.387**	<0.348
ppb	MW 228.0	<0.114	<0.102	<0.105	**<0.107**	<0.079

Chrysene

total ug		2.0	<2.0	<2.0	**<2.0**	<2.0
(ug / dscm)		0.676	<0.606	<0.622	**<0.635**	<0.466
(ug / min)		0.262	<0.229	<0.235	**<0.242**	<0.217
ppb	MW 228.0	0.071	<0.064	<0.066	**<0.067**	<0.049

Bis(2-ethylhexyl)phthalate

total ug		21.0	19.0	25.0	**21.7**	11.0
(ug / dscm)		7.098	5.761	7.778	**6.879**	2.561
(ug / min)		2.748	2.177	2.934	**2.620**	1.195
ppb	MW 390.6	0.437	0.355	0.479	**0.423**	0.158

Di-n-octyl phthalate

total ug		<5.2	<5.2	<5.2	**<5.2**	<5.2
(ug / dscm)		<1.757	<1.577	<1.618	**<1.651**	<1.210
(ug / min)		<0.680	<0.596	<0.610	**<0.629**	<0.565
ppb	MW 390.6	<0.108	<0.097	<0.100	**<0.102**	<0.074

Benzo(b)fluoranthene

total ug		<4.0	<4.0	<4.0	**<4.0**	<4.0
(ug / dscm)		<1.352	<1.213	<1.245	**<1.270**	<0.931
(ug / min)		<0.523	<0.458	<0.470	**<0.484**	<0.435
ppb	MW 252.0	<0.129	<0.116	<0.119	**<0.121**	<0.089

Benzo(k)fluoranthene

total ug		<4.4	<4.4	<4.4	**<4.4**	<4.4
(ug / dscm)		<1.487	<1.334	<1.369	**<1.397**	<1.024
(ug / min)		<0.576	<0.504	<0.516	**<0.532**	<0.478
ppb	MW 252.0	<0.142	<0.127	<0.131	**<0.133**	<0.098

TABLE 4 Continued...
(page 9 of 9)
RTS #1 WASTE FEED
EPA Test Method 0010 - Modified Method 5

Benzo(a)pyrene

total ug		<3.2	<3.2	<3.2	**<3.2**	<3.2
(ug / dscm)		<1.082	<0.970	<0.996	**<1.016**	<0.745
(ug / min)		<0.419	<0.367	<0.376	**<0.387**	<0.348
ppb	MW 252.0	<0.103	<0.093	<0.095	**<0.097**	<0.071

Indeno(1,2,3-cd)pyrene

total ug		<2.4	<2.4	<2.4	**<2.4**	<2.4
(ug / dscm)		<0.811	<0.728	<0.747	**<0.762**	<0.559
(ug / min)		<0.314	<0.275	<0.282	**<0.290**	<0.261
ppb	MW 276.0	<0.071	<0.063	<0.065	**<0.066**	<0.049

Dibenzo(a,h)anthracene

total ug		<4.0	<4.0	<4.0	**<4.0**	<4.0
(ug / dscm)		<1.352	<1.213	<1.245	**<1.270**	<0.931
(ug / min)		<0.523	<0.458	<0.470	**<0.484**	<0.435
ppb	MW 278.0	<0.117	<0.105	<0.108	**<0.110**	<0.081

Benzo(ghi)perylene

total ug		<2.8	<2.8	<2.8	**<2.8**	<2.8
(ug / dscm)		<0.946	<0.849	<0.871	**<0.889**	<0.652
(ug / min)		<0.366	<0.321	<0.329	**<0.339**	<0.304
ppb	MW 276.0	<0.082	<0.074	<0.076	**<0.077**	<0.057

Definitions:

DSCFM = Dry Standard Cubic Feet per Minute

ug / dscm = microgram per dry standard cubic meter

ug / min = emission rate, micrograms per minute

ppb = parts per billion

T std. = Standard Temerature, °F = 68

Calculations:

DSCM = DSCF * 0.02832

ug /min = 0.02832 * DSCFM * (ug / dscm)

ug / dscm = total ug / sample vol., dscm

ppb = ug / dscm * 22.4 * (T std. + 460) / 492 / M.W.

TABLE 5
RTS #2 WASTE FEED
LLNL Bldg. 292 MSO
GSS Inlet & Catalytic Converter Outlet
EPA Test Method 0010 - Modified Method 5

TEST#	1GSS -Inlet	2-GSS Inlet	3-GSS Inlet	AVERAGE	1-Cat. Out
TEST DATE	8/26/98	8/26/98	8/26/98		8/26/98
TEST TIME	0903-1216	1309-1616	1636-2002		1210-1510
SAMPLE VOLUME (DSCF)	158.170	126.098	112.188	**111.477**	132.838
SAMPLE VOLUME (DSCM)	2.959	3.298	3.214	**3.157**	3.762
FLOW RATE (DSCFM)	14.45	12.99	13.96	**13.45**	16.27
STACK GAS TEMP. °F	320.6	340.5	292.1	**320.5**	390
O_2, % vol. dry	10.4	10.0	9.3	**10.6**	
H_2O, % vol	3.2	5.4	4.5	**4.9**	
Aniline					
total ug	<40	<40	<40	**<40**	<40
(ug / dscm)	<13.519	<12.128	<12.445	**<12.697**	<10.633
(ug / min)	<5.532	<4.462	<4.920	**<4.971**	<4.899
ppb MW 93.0	<3.494	<3.135	<3.217	**<3.282**	<2.748
Phenol					
total ug	<1.2	<1.2	<1.2	**<1.2**	<1.2
(ug / dscm)	<0.406	<0.364	<0.373	**<0.381**	<0.319
(ug / min)	<0.166	<0.134	<0.148	**<0.149**	<0.147
ppb MW 94.0	<0.104	<0.093	<0.095	**<0.097**	<0.082
Bis(2-chloroethyl)ether					
total ug	<3.2	<3.2	<3.2	**<3.2**	<3.2
(ug / dscm)	<1.082	<0.970	<0.996	**<1.016**	<0.851
(ug / min)	<0.443	<0.357	<0.394	**<0.398**	<0.392
ppb MW 143.0	<0.182	<0.163	<0.167	**<0.171**	<0.143
2-Chlorophenol					
total ug	<2.0	<2.0	<2.0	**<2.0**	<2.0
(ug / dscm)	<0.676	<0.606	<0.622	**<0.635**	<0.532
(ug / min)	<0.277	<0.223	<0.246	**<0.249**	<0.245
ppb MW 128.6	<0.126	<0.113	<0.116	**<0.119**	<0.099
1,3-Dichlorobenzene					
total ug	<6.0	<6.0	<6.0	**<6.0**	<6.0
(ug / dscm)	<2.028	<1.819	<1.867	**<1.905**	<1.595
(ug / min)	<0.830	<0.669	<0.738	**<0.746**	<0.735
ppb MW 147.0	<0.332	<0.297	<0.305	**<0.311**	<0.261

TABLE 5 Continued...

(page 2 of 9)

RTS #2 WASTE FEED

EPA Test Method 0010 - Modified Method 5

1-4-Dichlorobenzene

total ug		<6.0	<6.0	<6.0	**<6.0**	<6.0
(ug / dscm)		<2.028	<1.819	<1.867	**<1.905**	<1.595
(ug / min)		<0.830	<0.669	<0.738	**<0.746**	<0.735
ppb	MW 147.0	<0.332	<0.297	<0.305	**<0.311**	<0.261

1,2-Dichlorobenzene

total ug		<6.8	<6.8	<6.8	**<6.8**	<6.8
(ug / dscm)		<2.298	<2.062	<2.116	**<2.159**	<1.808
(ug / min)		<0.941	<0.758	<0.836	**<0.845**	<0.833
ppb	MW 147.0	<0.376	<0.337	<0.346	**<0.353**	<0.296

2-Methylphenol

total ug		<4.8	<4.8	<4.8	**<4.8**	<4.8
(ug / dscm)		<1.622	<1.455	<1.493	**<1.524**	<1.276
(ug / min)		<0.664	<0.535	<0.590	**<0.597**	<0.588
ppb	MW 104.1	<0.375	<0.336	<0.345	**<0.352**	<0.295

Bis(2-chloroisopropyl)ether

total ug		<4.4	<4.4	<4.4	**<4.4**	<4.4
(ug / dscm)		<1.487	<1.334	<1.369	**<1.397**	<1.170
(ug / min)		<0.609	<0.491	<0.541	**<0.547**	<0.539
ppb	MW 132.1	<0.271	<0.243	<0.249	**<0.254**	<0.213

4-Methylphenol

total ug		<6.4	<6.4	<6.4	**<6.4**	<6.4
(ug / dscm)		<2.163	<1.940	<1.991	**<2.032**	<1.701
(ug / min)		<0.885	<0.714	<0.787	**<0.795**	<0.784
ppb	MW 104.1	<0.500	<0.448	<0.460	**<0.469**	<0.393

N-Nitroso-di-N-Propylamine

total ug		<4.4	<4.4	<4.4	**<4.4**	<4.4
(ug / dscm)		<1.487	<1.334	<1.369	**<1.397**	<1.170
(ug / min)		<0.609	<0.491	<0.541	**<0.547**	<0.539
ppb	MW 130.0	<0.275	<0.247	<0.253	**<0.258**	<0.216

Hexachloroethane

total ug		<4.4	<4.4	<4.4	**<4.4**	<4.4
(ug / dscm)		<1.487	<1.334	<1.369	**<1.397**	<1.170
(ug / min)		<0.609	<0.491	<0.541	**<0.547**	<0.539
ppb	MW 236.7	<0.151	<0.135	<0.139	**<0.142**	<0.119

Nitrobenzene

total ug		<3.2	<3.2	<3.2	**<3.2**	<3.2
(ug / dscm)		<1.082	<0.970	<0.996	**<1.016**	<0.851
(ug / min)		<0.443	<0.357	<0.394	**<0.398**	<0.392
ppb	MW 123.1	<0.211	<0.189	<0.194	**<0.198**	<0.166

TABLE 5 Continued...

(page 3 of 9)

RTS #2 WASTE FEED

EPA Test Method 0010 - Modified Method 5

Isophorone

total ug		<4.0	<4.0	<4.0	**<4.0**	<4.0
(ug / dscm)		<1.352	<1.213	<1.245	**<1.270**	<1.063
(ug / min)		<0.553	<0.446	<0.492	**<0.497**	<0.490
ppb	MW 138.2	<0.235	<0.211	<0.216	**<0.221**	<0.185

2-Nitrophenol

total ug		<4.8	<4.8	<4.8	**<4.8**	9.7
(ug / dscm)		<1.622	<1.455	<1.493	**<1.524**	2.578
(ug / min)		<0.664	<0.535	<0.590	**<0.597**	<1.188
ppb	MW 139.1	<0.280	<0.252	<0.258	**<0.263**	0.446

2,4-Dimethylphenol

total ug		<40.0	<40.0	<40.0	**<40.0**	<40.0
(ug / dscm)		<13.519	<12.128	<12.445	**<12.697**	<10.633
(ug / min)		<5.532	<4.462	<4.920	**<4.971**	<4.899
ppb	MW 122.2	<2.659	<2.386	<2.448	**<2.498**	<2.092

Bis(2-chloroethoxy)methane

total ug		<4.8	<4.8	<4.8	**<4.8**	<4.8
(ug / dscm)		<1.622	<1.455	<1.493	**<1.524**	<1.276
(ug / min)		<0.664	<0.535	<0.590	**<0.597**	<0.588
ppb	MW 173.0	<0.225	<0.202	<0.208	**<0.212**	<0.177

2,4-Dichlorophenol

total ug		<4.8	<4.8	<4.8	**<4.8**	<4.8
(ug / dscm)		<1.622	<1.455	<1.493	**<1.524**	<1.276
(ug / min)		<0.664	<0.535	<0.590	**<0.597**	<0.588
ppb	MW 163.0	<0.239	<0.215	<0.220	**<0.225**	<0.188

1,2,4-Trichlorobenzene

total ug		<8.8	<8.8	<8.8	**<8.8**	<8.8
(ug / dscm)		<2.974	<2.668	<2.738	**<2.793**	<2.339
(ug / min)		<1.217	<0.982	<1.082	**<1.094**	<1.078
ppb	MW 181.5	<0.394	<0.353	<0.363	**<0.370**	<0.310

Napthalene

total ug		<7.6	<7.6	<7.6	**<7.6**	<7.6
(ug / dscm)		<2.569	<2.304	<2.365	**<2.413**	<2.020
(ug / min)		<1.051	<0.848	<0.935	**<0.945**	<0.931
ppb	MW 128.0	<0.482	<0.433	<0.444	**<0.453**	<0.379

4-Chloroaniline

total ug		<40.0	<40.0	<40.0	**<40.0**	<40.0
(ug / dscm)		<13.519	<12.128	<12.445	**<12.697**	<10.633
(ug / min)		<5.532	<4.462	<4.920	**<4.971**	<4.399
ppb	MW 127.6	<2.547	<2.285	<2.345	**<2.392**	<2.003

TABLE 5 Continued...

(page 4 of 9)

RTS #2 WASTE FEED

EPA Test Method 0010 - Modified Method 5

Hexachlorobutadiene

total ug		<4.0	<4.0	<4.0	**<4.0**	<4.0
(ug / dscm)		<1.352	<1.213	<1.245	**<1.270**	<1.063
(ug / min)		<0.553	<0.446	<0.492	**<0.497**	<0.490
ppb	MW 260.8	<0.125	<0.112	<0.115	**<0.117**	<0.098

4-Chloro-3-Methylphenol

total ug		<5.6	<5.6	<5.6	**<5.6**	<5.6
(ug / dscm)		<1.893	<1.698	<1.742	**<1.778**	<1.489
(ug / min)		<0.775	<0.625	<0.689	**<0.696**	<0.686
ppb	MW 142.6	<0.319	<0.286	<0.294	**<0.300**	<0.251

2-Methylnaphthalene

total ug		<7.2	<7.2	<7.2	**<7.2**	<7.2
(ug / dscm)		<2.433	<2.183	<2.240	**<2.286**	<1.914
(ug / min)		<0.996	<0.803	<0.886	**<0.895**	<0.882
ppb	MW 142.0	<0.412	<0.370	<0.379	**<0.387**	<0.324

Hexachlorocyclopentadiene

total ug		<40.0	<40.0	<40.0	**<40.0**	<40.0
(ug / dscm)		<13.519	<12.128	<12.445	**<12.697**	<10.633
(ug / min)		<5.532	<4.462	<4.920	**<4.971**	<4.899
ppb	MW 272.8	<1.191	<1.069	<1.097	**<1.119**	<0.937

2,4,6-Trichlorophenol

total ug		<4.8	<4.8	<4.8	**<4.8**	<4.8
(ug / dscm)		<1.622	<1.455	<1.493	**<1.524**	<1.276
(ug / min)		<0.664	<0.535	<0.590	**<0.597**	<0.588
ppb	MW 197.5	<0.197	<0.177	<0.182	**<0.185**	<0.155

2,4,5-Trichlorophenol

total ug		<6.8	<6.8	<6.8	**<6.8**	<6.8
(ug / dscm)		<2.298	<2.062	<2.116	**<2.159**	<1.808
(ug / min)		<0.941	<0.758	<0.836	**<0.845**	<0.833
ppb	MW 197.5	<0.280	<0.251	<0.258	**<0.263**	<0.220

2-Chloronaphthalene

total ug		<8.8	<8.8	<8.8	**<8.8**	<8.8
(ug / dscm)		<2.974	<2.668	<2.738	**<2.793**	<2.339
(ug / min)		<1.217	<0.982	<1.082	**<1.094**	<1.078
ppb	MW 162.6	<0.440	<0.394	<0.405	**<0.413**	<0.346

2-Nitroaniline

total ug		<40.0	<40.0	<40.0	**<40.0**	<40.0
(ug / dscm)		<13.519	<12.128	<12.445	**<12.697**	<10.633
(ug / min)		<5.532	<4.462	<4.920	**<4.971**	<4.899
ppb	MW 138.1	<2.353	<2.111	<2.166	**<2.210**	<1.851

TABLE 5 Continued...

(page 5 of 9)

RTS #2 WASTE FEED

EPA Test Method 0010 - Modified Method 5

Dimethylphthalate

total ug		<2.8	<2.8	<2.8	**<2.8**	<2.8
(ug / dscm)		<0.946	<0.849	<0.871	**<0.889**	<0.744
(ug / min)		<0.387	<0.312	<0.344	**<0.348**	<0.343
ppb	MW 194.2	<0.117	<0.105	<0.108	**<0.110**	<0.092

Acenaphthylene

total ug		<6.4	<6.4	<6.4	**<6.4**	<6.4
(ug / dscm)		<2.163	<1.940	<1.991	**<2.032**	<1.701
(ug / min)		<0.885	<0.714	<0.787	**<0.795**	<0.784
ppb	MW 152.0	<0.342	<0.307	<0.315	**<0.321**	<0.269

2,6-Dinitrotoluene

total ug		<4.0	<4.0	<4.0	**<4.0**	<4.0
(ug / dscm)		<1.352	<1.213	<1.245	**<1.270**	<1.063
(ug / min)		<0.553	<0.446	<0.492	**<0.497**	<0.490
ppb	MW 182.1	<0.178	<0.160	<0.164	**<0.168**	<0.140

3-Nitroaniline

total ug		<40.0	<40.0	<40.0	**<40.0**	<40.0
(ug / dscm)		<13.519	<12.128	<12.445	**<12.697**	<10.633
(ug / min)		<5.532	<4.462	<4.920	**<4.971**	<4.899
ppb	MW 138.1	<2.353	<2.111	<2.166	**<2.210**	<1.851

Acenaphthene

total ug		<8.0	<8.0	<8.0	**<8.0**	<8.0
(ug / dscm)		<2.704	<2.426	<2.489	**<2.539**	<2.127
(ug / min)		<1.106	<0.892	<0.984	**<0.994**	<0.980
ppb	MW 154.0	<0.422	<0.379	<0.389	**<0.396**	<0.332

2,4-Dinitrophenol

total ug		<40.0	<40.0	<40.0	**<40.0**	<40.0
(ug / dscm)		<13.519	<12.128	<12.445	**<12.697**	<10.633
(ug / min)		<5.532	<4.462	<4.920	**<4.971**	<4.899
ppb	MW 184.1	<1.765	<1.584	<1.625	**<1.658**	<1.388

4-Nitrophenol

total ug		<40.0	<40.0	<40.0	**<40.0**	<40.0
(ug / dscm)		<13.519	<12.128	<12.445	**<12.697**	<10.633
(ug / min)		<5.532	<4.462	<4.920	**<4.971**	<4.899
ppb	MW 139.1	<2.336	<2.096	<2.151	**<2.194**	<1.838

Dibenzofuran

total ug		<40.0	<40.0	<40.0	**<40.0**	<40.0
(ug / dscm)		<13.519	<12.128	<12.445	**<12.697**	<10.633
(ug / min)		<5.532	<4.462	<4.920	**<4.971**	<4.899
ppb	MW 168.2	<1.932	<1.733	<1.779	**<1.815**	<1.520

TABLE 5 Continued...

(page 6 of 9)

RTS #2 WASTE FEED

EPA Test Method 0010 - Modified Method 5

2,4-Dinitrotoluene

total ug		<4.4	<4.4	<4.4	**<4.4**	<4.4
(ug / dscm)		<1.487	<1.334	<1.369	**<1.397**	<1.170
(ug / min)		<0.609	<0.491	<0.541	**<0.547**	<0.539
ppb	MW 182.1	<0.196	<0.176	<0.181	**<0.184**	<0.154

Diethyl phthalate

total ug		150.0	2.0	<1.6	**51.200**	<1.6
(ug / dscm)		50.697	0.606	<0.498	**17.267**	<0.425
(ug / min)		20.746	0.223	<0.197	**7.055**	0.196
ppb	MW 222.2	5.485	0.066	<0.054	**1.868**	<0.046

4-Chlorophenylphenylether

total ug		<7.2	<7.2	<7.2	**<7.2**	<7.2
(ug / dscm)		<2.433	<2.183	<2.240	**<2.286**	<1.914
(ug / min)		<0.996	<0.803	<0.886	**<0.895**	<0.882
ppb	MW 204.7	<0.286	<0.256	<0.263	**<0.268**	<0.225

Fluorene

total ug		<5.2	<5.2	<5.2	**<5.2**	<5.2
(ug / dscm)		<1.757	<1.577	<1.618	**<1.651**	<1.382
(ug / min)		<0.719	<0.580	<0.640	**<0.646**	<0.637
ppb	MW 166.0	<0.255	<0.228	<0.234	**<0.239**	<0.200

4-Nitroaniline

total ug		<40.0	<40.0	<40.0	**<40.0**	<40.0
(ug / dscm)		<13.519	<12.128	<12.445	**<12.697**	<10.633
(ug / min)		<5.532	<4.462	<4.920	**<4.971**	<4.899
ppb	MW 138.1	<2.353	<2.111	<2.166	**<2.210**	<1.851

4,6-Dintro-2-methylphenol

total ug		<4.8	<4.8	<4.8	**<4.8**	<4.8
(ug / dscm)		<1.622	<1.455	<1.493	**<1.524**	<1.276
(ug / min)		<0.664	<0.535	<0.590	**<0.597**	<0.588
ppb	MW 198.1	<0.197	<0.177	<0.181	**<0.185**	<0.155

N-Nitrosodiphenylamine

total ug		<14.0	<14.0	<14.0	**<14.0**	<14.0
(ug / dscm)		<4.732	<4.245	<4.356	**<4.444**	<3.721
(ug / min)		<1.936	<1.562	<1.722	**<1.740**	<1.715
ppb	MW 198.2	<0.574	<0.515	<0.528	**<0.539**	<0.451

4-Bromophenylphenylether

total ug		<6.4	<6.4	<6.4	**<6.4**	<6.4
(ug / dscm)		<2.163	<1.940	<1.991	**<2.032**	<1.701
(ug / min)		<0.885	<0.714	<0.787	**<0.795**	<0.784
ppb	MW 221.5	<0.235	<0.211	<0.216	**<0.220**	<0.185

TABLE 5 Continued...
(page 7 of 9)
RTS #2 WASTE FEED
EPA Test Method 0010 - Modified Method 5

Hexachlorobenzene

total ug		<4.0	<4.0	<4.0	**<4.0**	<4.0
(ug / dscm)		<1.352	<1.213	<1.245	**<1.270**	<1.063
(ug / min)		<0.553	<0.446	<0.492	**<0.497**	<0.490
ppb	MW 284.8	<0.114	<0.102	<0.105	**<0.107**	<0.090

Pentachlorophenol

total ug		<6.0	<6.0	<6.0	**<6.0**	<6.0
(ug / dscm)		<2.028	<1.819	<1.867	**<1.905**	<1.595
(ug / min)		<0.830	<0.669	<0.738	**<0.746**	<0.735
ppb	MW 266.3	<0.183	<0.164	<0.169	**<0.172**	<0.144

Phenanthrene

total ug		4.50	2.50	<2.40	**3.1**	<2.4
(ug / dscm)		1.521	0.758	<0.747	**1.009**	<0.638
(ug / min)		0.622	0.279	<0.295	**0.399**	0.294
ppb	MW 176.0	0.208	0.104	<0.102	**0.138**	<0.087

Anthracene

total ug		<4.4	<4.4	<4.4	**<4.4**	<4.4
(ug / dscm)		<1.487	<1.334	<1.369	**<1.397**	<1.170
(ug / min)		<0.609	<0.491	<0.541	**<0.547**	<0.539
ppb	MW 176.0	<0.203	<0.182	<0.187	**<0.191**	<0.160

Carbazole

total ug		<1.2	<1.2	<1.2	**<1.2**	<1.2
(ug / dscm)		<0.406	<0.364	<0.373	**<0.381**	<0.319
(ug / min)		<0.166	<0.134	<0.148	**<0.149**	<0.147
ppb	MW 167.0	<0.058	<0.052	<0.054	**<0.055**	<0.046

Di-n-butyl phthalate

total ug		18	4	<4.0	**8.7**	<4.0
(ug / dscm)		6.084	1.213	<1.245	**2.847**	<1.063
(ug / min)		2.490	0.446	<0.492	**1.143**	0.490
ppb	MW 278.4	0.525	0.105	<0.107	**0.246**	<0.092

Fluoranthene

total ug		<4.0	<4.0	<4.0	**<4.0**	<4.0
(ug / dscm)		<1.352	<1.213	<1.245	**<1.270**	<1.063
(ug / min)		<0.553	<0.446	<0.492	**<0.497**	<0.490
ppb	MW 202.0	<0.161	<0.144	<0.148	**<0.151**	<0.127

Pyrene

total ug		<2.0	<2.0	<2.0	**<2.0**	<2.0
(ug / dscm)		<0.676	<0.606	<0.622	**<0.635**	<0.532
(ug / min)		<0.277	<0.223	<0.246	**<0.249**	<0.245
ppb	MW 202.0	<0.080	<0.072	<0.074	**<0.076**	<0.063

TABLE 5 Continued...

(page 8 of 9)

RTS #2 WASTE FEED

EPA Test Method 0010 - Modified Method 5

Benzyl butyl phthalate

total ug		<5.2	<5.2	<5.2	**<5.2**	<5.2
(ug / dscm)		<1.757	<1.577	<1.618	**<1.651**	<1.382
(ug / min)		<0.719	<0.580	<0.640	**<0.646**	<0.637
ppb	MW 312.4	<0.135	<0.121	<0.124	**<0.127**	<0.106

3,3-Dichlorobenzidine

total ug		<40.0	<40.0	<40.0	**<40.0**	<40.0
(ug / dscm)		<13.519	<12.128	<12.445	**<12.697**	<10.633
(ug / min)		<5.532	<4.462	<4.920	**<4.971**	<4.899
ppb	MW 253.1	<1.284	<1.152	<1.182	**<1.206**	<1.010

Benzo(a)anthracene

total ug		<3.2	<3.2	<3.2	**<3.2**	<3.2
(ug / dscm)		<1.082	<0.970	<0.996	**<1.016**	<0.851
(ug / min)		<0.443	<0.357	<0.394	**<0.398**	<0.392
ppb	MW 228.0	<0.114	<0.102	<0.105	**<0.107**	<0.090

Chrysene

total ug		<2.0	<2.0	<2.0	**<2.0**	<2.0
(ug / dscm)		<0.676	<0.606	<0.622	**<0.635**	<0.532
(ug / min)		<0.277	<0.223	<0.246	**<0.249**	<0.245
ppb	MW 228.0	<0.071	<0.064	<0.066	**<0.067**	<0.056

Bis(2-ethylhexyl)phthalate

total ug		15.0	23.0	11.0	**16.3**	<8.0
(ug / dscm)		5.070	6.974	3.422	**5.155**	<2.127
(ug / min)		2.075	2.565	1.353	**1.998**	<0.980
ppb	MW 390.6	0.312	0.429	0.211	**0.317**	<0.131

Di-n-octyl phthalate

total ug		<5.2	<5.2	<5.2	**<5.2**	<5.2
(ug / dscm)		<1.757	<1.577	<1.618	**<1.651**	<1.382
(ug / min)		<0.719	<0.580	<0.640	**<0.646**	<0.637
ppb	MW 390.6	<0.108	<0.097	<0.100	**<0.102**	<0.085

Benzo(b)fluoranthene

total ug		<4.0	<4.0	<4.0	**<4.0**	<4.0
(ug / dscm)		<1.352	<1.213	<1.245	**<1.270**	<1.063
(ug / min)		<0.553	<0.446	<0.492	**<0.497**	<0.490
ppb	MW 252.0	<0.129	<0.116	<0.119	**<0.121**	<0.101

Benzo(k)fluoranthene

total ug		<4.4	<4.4	<4.4	**<4.4**	<4.4
(ug / dscm)		<1.487	<1.334	<1.369	**<1.397**	<1.170
(ug / min)		<0.609	<0.491	<0.541	**<0.547**	<0.539
ppb	MW 252.0	<0.142	<0.127	<0.131	**<0.133**	<0.112

TABLE 5 Continued...

(page 9 of 9)

RTS #2 WASTE FEED

EPA Test Method 0010 - Modified Method 5

Benzo(a)pyrene

total ug		<3.2	<3.2	<3.2	**<3.2**	<3.2
(ug / dscm)		<1.082	<0.970	<0.996	**<1.016**	<0.851
(ug / min)		<0.443	<0.357	<0.394	**<0.398**	<0.392
ppb	MW 252.0	<0.103	<0.093	<0.095	**<0.097**	<0.081

Indeno(1,2,3-cd)pyrene

total ug		<2.4	<2.4	<2.4	**<2.4**	<2.4
(ug / dscm)		<0.811	<0.728	<0.747	**<0.762**	<0.638
(ug / min)		<0.332	<0.268	<0.295	**<0.298**	<0.294
ppb	MW 276.0	<0.071	<0.063	<0.065	**<0.066**	<0.056

Dibenzo(a,h)anthracene

total ug		<4.0	<4.0	<4.0	**<4.0**	<4.0
(ug / dscm)		<1.352	<1.213	<1.245	**<1.270**	<1.063
(ug / min)		<0.553	<0.446	<0.492	**<0.497**	<0.490
ppb	MW 278.0	<0.117	<0.105	<0.108	**<0.110**	<0.092

Benzo(ghi)perylene

total ug		<2.8	<2.8	<2.8	**<2.8**	<2.8
(ug / dscm)		<0.946	<0.849	<0.871	**<0.889**	<0.744
(ug / min)		<0.387	<0.312	<0.344	**<0.348**	<0.343
ppb	MW 276.0	<0.082	<0.074	<0.076	**<0.077**	<0.065

Definitions:

DSCFM = Dry Standard Cubic Feet per Minute

ug / dscm = microgram per dry standard cubic meter

ug / sec = emission rate, micrograms per second

ppb = parts per billion

T std. = Standard Temerature, °F = 68

Calculations:

DSCM = DSCF * 0.02832

ug /min = 0.02832 * DSCFM * (ug / dscm)

ug / dscm = total ug / sample vol., dscm

ppb = ug / dscm * 22.4 * (T std. + 460) / 492 / M.W.

TABLE 6
LLNL Bldg. 292 MSO
GSS Filter& Catalytic Converter Outlets - RTS #1 Waste Feed Volatile Emissions
EPA Test Method 0030 - VOST

TEST #	1-GSS Out	2-GSS Out	3-GSS Out	AVERAGE	Cat. Out
TEST DATE	8/18/98	8/18/98	8/18/98		8/18/98
TEST TIME	1059-1215	1234-1350	1424-1546		1614-1740
SAMPLE VOLUME (Std. liters)	57.020	53.690	54.309	**55.006**	58.688
SAMPLE VOLUME (DSCM)	0.057	0.054	0.054	**0.055**	0.059
FLOW RATE (DSCFM)	14.66	14.27	13.52	**14.15**	16.48
Chloromethane					
total µg	1.120	0.330	3.940	**1.797**	0.178
(µg / dscm)	19.642	6.146	72.548	**32.779**	3.033
(µg / min)	8.155	2.484	27.778	**12.805**	1.416
ppb MW = 50.5	9.350	2.926	34.534	**15.603**	1.444
Bromomethane					
total µg	0.191	0.029	0.096	**0.105**	0.172
(µg / dscm)	3.350	0.540	1.768	**1.886**	2.931
(µg / min)	1.391	0.218	0.677	**0.762**	1.368
ppb MW = 95.0	0.848	0.137	0.447	**0.477**	0.742
Vinyl Chloride					
total µg	<0.039	<0.039	<0.039	**<0.039**	<0.039
(µg / dscm)	<0.684	<0.726	<0.718	**<0.709**	<0.665
(µg / min)	<0.284	<0.294	<0.275	**<0.284**	<0.310
ppb MW = 62.5	<0.263	<0.279	<0.276	**<0.273**	<0.256
Chloroethane					
total µg	<0.0210	<0.0210	<0.0210	**<0.0210**	<0.0210
(µg / dscm)	<0.3683	<0.3911	<0.3867	**<0.3820**	<0.3578
(µg / min)	<0.1529	<0.1581	<0.1481	**<0.1530**	<0.1670
ppb MW = 64.5	<0.1372	<0.1457	<0.1441	**<0.1423**	<0.1333
Methylene Chloride					
total µg	9.900	6.600	4.210	**6.903**	3.700
(µg / dscm)	173.624	122.927	77.519	**124.690**	63.045
(µg / min)	72.084	49.678	29.681	**50.481**	29.424
ppb MW = 84.9	49.161	34.806	21.949	**35.305**	17.851
Acetone					
total µg	7.400	11.800	1.550	**6.917**	0.830
(µg / dscm)	129.780	219.779	28.540	**126.033**	14.143
(µg / min)	53.881	88.819	10.928	**51.209**	6.601
ppb MW = 58.1	53.715	90.966	11.813	**52.165**	5.854
Carbon Disulfide					
total µg	<0.054	<0.054	<0.054	**<0.054**	<0.054
(µg / dscm)	<0.947	<1.006	<0.994	**<0.982**	<0.920
(µg / min)	<0.393	<0.406	<0.381	**<0.393**	<0.429
ppb MW = 76.1	<0.299	<0.318	<0.314	**<0.310**	<0.291

TABLE 6 - cont. (page 2 of 4)

GSS Filter Outlet - RTS #1 Waste Feed Volatile Emissions
EPA Test Method 0030 - VOST

1,1-Dichloroethene						
total µg		0.268	0.106	0.064	**0.146**	0.142
(µg / dscm)		4.700	1.974	1.178	**2.618**	2.420
(µg / min)		1.951	0.798	0.451	**1.067**	1.129
ppb	MW = 97.0	1.165	0.489	0.292	**0.649**	0.600
1,1-Dichloroethane						
total µg		<0.012	<0.012	<0.012	**<0.012**	<0.012
(µg / dscm)		<0.210	<0.224	<0.221	**<0.218**	<0.204
(µg / min)		<0.087	<0.090	<0.085	**<0.087**	<0.095
ppb	MW = 99.0	<0.051	<0.054	<0.054	**<0.053**	<0.050
1,2-Dichloroethene						
total µg		<0.021	<0.021	<0.021	**<0.021**	<0.021
(µg / dscm)		<0.368	<0.391	<0.387	**<0.382**	<0.358
(µg / min)		<0.153	<0.158	<0.148	**<0.153**	<0.167
ppb	MW = 97.0	<0.091	<0.097	<0.096	**<0.095**	<0.089
Chloroform						
total µg		<0.024	<0.024	<0.024	**<0.024**	<0.024
(µg / dscm)		<0.421	<0.447	<0.442	**<0.437**	<0.409
(µg / min)		<0.175	<0.181	<0.169	**<0.175**	<0.191
ppb	MW = 119.4	<0.085	<0.090	<0.089	**<0.088**	<0.082
1,2-Dichlorethane						
total µg		<0.018	<0.018	<0.018	**<0.018**	<0.018
(µg / dscm)		<0.316	<0.335	<0.331	**<0.327**	<0.307
(µg / min)		<0.131	<0.135	<0.127	**<0.131**	<0.143
ppb	MW = 99.0	<0.077	<0.081	<0.080	**<0.080**	<0.074
2-Butanone						
total µg		<0.108	0.190	<0.108	**<0.135**	<0.108
(µg / dscm)		<1.894	3.539	<1.989	**<2.474**	<1.840
(µg / min)		<0.786	1.430	<0.761	**<0.993**	<0.859
ppb	MW = 72.1	<0.631	1.180	<0.663	**<0.825**	<0.613
1,1,1-Trichloroethane						
total µg		0.137	<0.044	<0.042	**<0.074**	0.250
(µg / dscm)		2.403	<0.820	<0.773	**<1.332**	4.260
(µg / min)		0.998	<0.331	<0.296	**<0.542**	1.988
ppb	MW = 133.4	0.433	<0.148	<0.139	**<0.240**	0.768
Carbon Tetrachloride						
total µg		<0.048	<0.048	<0.048	**<0.048**	<0.048
(µg / dscm)		<0.842	<0.894	<0.884	**<0.873**	<0.818
(µg / min)		<0.349	<0.361	<0.338	**<0.350**	<0.382
ppb	MW = 153.8	<0.132	<0.140	<0.138	**<0.136**	<0.128
Bromodichloromethane						
total µg		<0.033	<0.033	<0.033	**<0.033**	<0.033
(µg / dscm)		<0.579	<0.615	<0.608	**<0.600**	<0.562
(µg / min)		<0.240	<0.248	<0.233	**<0.240**	<0.262
ppb	MW = 163.8	<0.085	<0.090	<0.089	**<0.088**	<0.083

TABLE 6 - cont. (page 3 of 4)

GSS Filter Outlet - RTS #1 Waste Feed Volatile Emissions
EPA Test Method 0030 - VOST

1,2-Dichloropropane						
total µg		<0.024	0.150	<0.024	**<0.066**	<0.024
(µg / dscm)		<0.421	2.794	<0.442	**<1.219**	<0.409
(µg / min)		<0.175	1.129	<0.169	**<0.491**	<0.191
ppb	MW = 113.0	<0.090	0.594	<0.094	**<0.259**	<0.087
cis-1,3-Dichloropropene						
total µg		<0.021	<0.021	<0.021	**<0.021**	<0.021
(µg / dscm)		<0.368	<0.391	<0.387	**<0.382**	<0.358
(µg / min)		<0.153	<0.158	<0.148	**<0.153**	<0.167
ppb	MW = 111.0	<0.080	<0.085	<0.084	**<0.083**	<0.077
Trichloroethene						
total µg		<0.027	<0.027	<0.027	**<0.027**	<0.027
(µg / dscm)		<0.474	<0.503	<0.497	**<0.491**	<0.460
(µg / min)		<0.197	<0.203	<0.190	**<0.197**	<0.215
ppb	MW = 131.4	<0.087	<0.092	<0.091	**<0.090**	<0.084
Dibromochloromethane						
total µg		<0.024	<0.024	<0.024	**<0.024**	<0.024
(µg / dscm)		<0.421	<0.447	<0.442	**<0.437**	<0.409
(µg / min)		<0.175	<0.181	<0.169	**<0.175**	<0.191
ppb	MW = 208.3	<0.049	<0.052	<0.051	**<0.050**	<0.047
1,1,2-Trichloroethane						
total µg		<0.048	<0.048	<0.048	**<0.048**	<0.048
(µg / dscm)		<0.842	<0.894	<0.884	**<0.873**	<0.818
(µg / min)		<0.349	<0.361	<0.338	**<0.350**	<0.382
ppb	MW = 133.4	<0.152	<0.161	<0.159	**<0.157**	<0.147
Benzene						
total µg		0.124	0.107	0.092	**0.108**	0.320
(µg / dscm)		2.175	1.993	1.694	**1.954**	5.453
(µg / min)		0.903	0.805	0.649	**0.786**	2.545
ppb	MW = 78.1	0.669	0.613	0.521	**0.601**	1.678
trans-1,3-Dichloropropene						
total µg		<0.021	<0.021	<0.021	**<0.021**	<0.021
(µg / dscm)		<0.368	<0.391	<0.387	**<0.382**	<0.358
(µg / min)		<0.153	<0.158	<0.148	**<0.153**	<0.167
ppb	MW = 111.0	<0.080	<0.085	<0.084	**<0.083**	<0.077
Bromoform						
total µg		<0.036	<0.036	<0.036	**<0.036**	<0.036
(µg / dscm)		<0.631	<0.671	<0.663	**<0.655**	<0.613
(µg / min)		<0.262	<0.271	<0.254	**<0.262**	<0.286
ppb	MW = 252.8	<0.060	<0.064	<0.063	**<0.062**	<0.058
4-Methyl-2-Pentanone						
total µg		<0.057	<0.057	<0.057	**<0.057**	<0.057
(µg / dscm)		<1.000	<1.062	<1.050	**<1.037**	<0.971
(µg / min)		<0.415	<0.429	<0.402	**<0.415**	<0.453
ppb	MW = 100.2	<0.240	<0.255	<0.252	**<0.249**	<0.233

TABLE 6 - cont. (page 4 of 4)

GSS Filter Outlet - RTS #1 Waste Feed Volatile Emissions
EPA Test Method 0030 - VOST

2-Hexanone

total µg		<0.093	<0.093	<0.093	**<0.093**	<0.093
(µg / dscm)		<1.631	<1.732	<1.712	**<1.692**	<1.585
(µg / min)		<0.677	<0.700	<0.656	**<0.678**	<0.740
ppb	MW = 100.2	<0.391	<0.416	<0.411	**<0.406**	<0.380

Tetrachloroethene

total µg		<0.024	<0.024	<0.024	**<0.024**	<0.024
(µg / dscm)		<0.421	<0.447	<0.442	**<0.437**	<0.409
(µg / min)		<0.175	<0.181	<0.169	**<0.175**	<0.191
ppb	MW = 165.8	<0.061	<0.065	<0.064	**<0.063**	<0.059

1,1,2,2-Tetrachloroethane

total µg		<0.042	<0.042	<0.042	**<0.042**	<0.042
(µg / dscm)		<0.737	<0.782	<0.773	**<0.764**	<0.716
(µg / min)		<0.306	<0.316	<0.296	**<0.306**	<0.334
ppb	MW = 167.9	<0.105	<0.112	<0.111	**<0.109**	<0.102

Toluene

total µg		0.139	0.630	0.790	**0.520**	0.318
(µg / dscm)		2.438	11.734	14.546	**9.573**	5.418
(µg / min)		1.012	4.742	5.570	**3.775**	2.529
ppb	MW = 92.1	0.636	3.063	3.797	**2.499**	1.414

Chlorobenzene

total µg		<0.027	<0.027	<0.027	**<0.027**	<0.027
(µg / dscm)		<0.474	<0.503	<0.497	**<0.491**	<0.460
(µg / min)		<0.197	<0.203	<0.190	**<0.197**	<0.215
ppb	MW = 112.6	<0.101	<0.107	<0.106	**<0.105**	<0.098

Ethylbenzene

total µg		0.023	<0.018	<0.018	**<0.020**	<0.018
(µg / dscm)		0.403	<0.335	<0.331	**<0.357**	<0.307
(µg / min)		0.167	<0.135	<0.127	**<0.143**	<0.143
ppb	MW = 106.2	0.091	<0.076	<0.075	**<0.081**	<0.069

Stryrene

total µg		0.025	<0.022	<0.021	**<0.023**	<0.021
(µg / dscm)		0.438	<0.410	<0.387	**<0.412**	<0.358
(µg / min)		0.182	<0.166	<0.148	**<0.165**	<0.167
ppb	MW = 104.1	0.101	<0.095	<0.089	**<0.095**	<0.083

Xylene (Total)

total µg		0.126	0.077	0.061	**0.088**	0.037
(µg / dscm)		2.210	1.434	1.123	**1.589**	0.630
(µg / min)		0.917	0.580	0.430	**0.642**	0.294
ppb	MW = 106.2	0.500	0.325	0.254	**0.360**	0.143

1,1,2-Trichlorotrifluoroethane

total µg		<0.600	<0.600	<0.600	**<0.600**	<0.600
(µg / dscm)		<10.523	<11.175	<11.048	**<10.915**	<10.224
(µg / min)		<4.369	<4.516	<4.230	**<4.372**	<4.771
ppb	MW = 187.4	<1.350	<1.434	<1.417	**<1.400**	<1.311

Definitions:

DSCFM = Dry Standard Cubic Feet per Minute

µg / dscm = microgram per dry standard cubic meter

µg / min = emission rate, micrograms per minute

ppb = parts per billion

Calculations:

µg /min = 0.02832 * DSCFM * (µg / dscm)

µg / dscm = total µg / sample vol., dscm

ppb = µg / dscm * 22.4 * (T std. + 460) / 492 / M.W.

T std. = Standard Temperature, °F = 68

TABLE 7
LLNL Bldg. 292 MSO
GSS Filter & Catalytic Converter Outlet - RTS #2 Waste Feed Volatile Emissions
EPA Test Method 0030 - VOST

TEST #	1-GSS Out	2-GSS Out	3-GSS Out	AVERAGE	Cat. Out
TEST DATE	8/26/98	8/26/98	8/26/98		8/26/98
TEST TIME	0903-1024	1048-1210	1229-1348		1410-1530
SAMPLE VOLUME (Std. liters)	54.288	57.824	58.668	**56.927**	57.301
SAMPLE VOLUME (DSCM)	0.054	0.058	0.059	**0.057**	0.057
FLOW RATE (DSCFM)	13.31	14.90	13.50	**13.90**	16.27
Chloromethane					
total µg	<0.021	<0.021	<0.021	**<0.021**	7.89
(µg / dscm)	<0.387	<0.363	<0.358	**<0.369**	137.694
(µg / min)	<0.146	<0.153	<0.137	**<0.145**	63.445
ppb MW = 50.5	<0.184	<0.173	<0.170	**<0.176**	65.545
Bromomethane					
total µg	0.855	0.103	0.242	**0.400**	0.175
(µg / dscm)	15.749	1.781	4.125	**7.219**	3.054
(µg / min)	5.937	0.752	1.577	**2.755**	1.407
ppb MW = 95.0	3.985	0.451	1.044	**1.827**	0.773
Vinyl Chloride					
total µg	<0.039	<0.039	<0.039	**<0.039**	<0.039
(µg / dscm)	<0.718	<0.674	<0.665	**<0.686**	<0.681
(µg / min)	<0.271	<0.285	<0.254	**<0.270**	<0.314
ppb MW = 62.5	<0.276	<0.259	<0.256	**<0.264**	<0.262
Chloroethane					
total µg	<0.0210	<0.0210	<0.0210	**<0.0210**	<0.0210
(µg / dscm)	<0.3868	<0.3632	<0.3579	**<0.3693**	<0.3665
(µg / min)	<0.1458	<0.1532	<0.1368	**<0.1453**	<0.1689
ppb MW = 64.5	<0.1441	<0.1353	<0.1334	**<0.1376**	<0.1365
Methylene Chloride					
total µg	3.930	4.700	9.000	**5.877**	8.400
(µg / dscm)	72.392	81.281	153.405	**102.360**	146.595
(µg / min)	27.287	34.298	58.650	**40.078**	67.546
ppb MW = 84.9	20.497	23.014	43.436	**28.983**	41.508
Acetone					
total µg	6.860	9.700	8.900	**8.487**	2.210
(µg / dscm)	126.364	167.751	151.701	**148.605**	38.568
(µg / min)	47.631	70.785	57.998	**58.805**	17.771
ppb MW = 58.1	52.301	69.431	62.788	**61.507**	15.963
Carbon Disulfide					
total µg	<0.054	<0.054	<0.054	**<0.054**	<0.054
(µg / dscm)	<0.995	<0.934	<0.920	**<0.950**	<0.942
(µg / min)	<0.375	<0.394	<0.352	**<0.374**	<0.434
ppb MW = 76.1	<0.314	<0.295	<0.291	**<0.300**	<0.298

TABLE 7 - cont. (page 2 of 4)

GSS Filter & Catalytic Converter Outlet - RTS #2 Waste Feed Volatile Emissions
EPA Test Method 0030 - VOST

1,1-Dichloroethene

total µg		0.020	0.106	0.354	**0.160**	0.142
(µg / dscm)		0.368	1.833	6.034	**2.745**	2.478
(µg / min)		0.139	0.774	2.307	**1.073**	1.142
ppb	MW = 97.0	0.091	0.454	1.495	**0.680**	0.614

1,1-Dichloroethane

total µg		<0.012	<0.012	<0.012	**<0.012**	<0.012
(µg / dscm)		<0.221	<0.208	<0.205	**<0.211**	<0.209
(µg / min)		<0.083	<0.088	<0.078	**<0.083**	<0.096
ppb	MW = 99.0	<0.054	<0.050	<0.050	**<0.051**	<0.051

1,2-Dichloroethene

total µg		<0.021	<0.021	<0.021	**<0.021**	<0.021
(µg / dscm)		<0.387	<0.363	<0.358	**<0.369**	<0.366
(µg / min)		<0.146	<0.153	<0.137	**<0.145**	<0.169
ppb	MW = 97.0	<0.096	<0.090	<0.089	**<0.092**	<0.091

Chloroform

total µg		<0.024	<0.024	<0.024	**<0.024**	<0.024
(µg / dscm)		<0.442	<0.415	<0.409	**<0.422**	<0.419
(µg / min)		<0.167	<0.175	<0.156	**<0.166**	<0.193
ppb	MW = 119.4	<0.089	<0.084	<0.082	**<0.085**	<0.084

1,2-Dichlorethane

total µg		<0.018	<0.018	<0.018	**<0.018**	<0.018
(µg / dscm)		<0.332	<0.311	<0.307	**<0.317**	<0.314
(µg / min)		<0.125	<0.131	<0.117	**<0.125**	<0.145
ppb	MW = 99.0	<0.081	<0.076	<0.074	**<0.077**	<0.076

2-Butanone

total µg		<0.108	<0.108	<0.108	**<0.108**	<0.108
(µg / dscm)		<1.989	<1.868	<1.841	**<1.899**	<1.885
(µg / min)		<0.750	<0.788	<0.704	**<0.747**	<0.868
ppb	MW = 72.1	<0.663	<0.623	<0.614	**<0.633**	<0.628

1,1,1-Trichloroethane

total µg		<0.042	<0.042	<0.042	**<0.042**	<0.042
(µg / dscm)		<0.774	<0.726	<0.716	**<0.739**	<0.733
(µg / min)		<0.292	<0.306	<0.274	**<0.291**	<0.338
ppb	MW = 133.4	<0.139	<0.131	<0.129	**<0.133**	<0.132

Carbon Tetrachloride

total µg		<0.048	<0.048	<0.048	**<0.048**	<0.048
(µg / dscm)		<0.884	<0.830	<0.818	**<0.844**	<0.838
(µg / min)		<0.333	<0.350	<0.313	**<0.332**	<0.386
ppb	MW = 153.8	<0.138	<0.130	<0.128	**<0.132**	<0.131

Bromodichloromethane

total µg		<0.033	<0.033	<0.033	**<0.033**	<0.033
(µg / dscm)		<0.608	<0.571	<0.562	**<0.580**	<0.576
(µg / min)		<0.229	<0.241	<0.215	**<0.228**	<0.265
ppb	MW = 163.8	<0.089	<0.084	<0.083	**<0.085**	<0.085

TABLE 7 - cont. (page 3 of 4)

GSS Filter & Catalytic Converter Outlet - RTS #2 Waste Feed Volatile Emissions
EPA Test Method 0030 - VOST

1,2-Dichloropropane						
total µg		<0.024	<0.024	0.205	**<0.084**	<0.024
(µg / dscm)		<0.442	<0.415	3.494	**<1.450**	<0.419
(µg / min)		<0.167	<0.175	1.336	**<0.559**	<0.193
ppb	MW = 113.0	<0.094	<0.088	0.743	**<0.309**	<0.089
cis-1,3-Dichloropropene						
total µg		<0.021	<0.021	<0.021	**<0.021**	<0.021
(µg / dscm)		<0.387	<0.363	<0.358	**<0.369**	<0.366
(µg / min)		<0.146	<0.153	<0.137	**<0.145**	<0.169
ppb	MW = 111.0	<0.084	<0.079	<0.078	**<0.080**	<0.079
Trichloroethene						
total µg		<0.027	<0.027	<0.027	**<0.027**	<0.027
(µg / dscm)		<0.497	<0.467	<0.460	**<0.475**	<0.471
(µg / min)		<0.187	<0.197	<0.176	**<0.187**	<0.217
ppb	MW = 131.4	<0.091	<0.085	<0.084	**<0.087**	<0.086
Dibromochloromethane						
total µg		<0.024	<0.024	<0.024	**<0.024**	<0.024
(µg / dscm)		<0.442	<0.415	<0.409	**<0.422**	<0.419
(µg / min)		<0.167	<0.175	<0.156	**<0.166**	<0.193
ppb	MW = 208.3	<0.051	<0.048	<0.047	**<0.049**	<0.048
1,1,2-Trichloroethane						
total µg		<0.048	<0.048	<0.048	**<0.048**	<0.048
(µg / dscm)		<0.884	<0.830	<0.818	**<0.844**	<0.838
(µg / min)		<0.333	<0.350	<0.313	**<0.332**	<0.386
ppb	MW = 133.4	<0.159	<0.150	<0.147	**<0.152**	<0.151
Benzene						
total µg		0.640	0.226	1.845	**0.904**	0.269
(µg / dscm)		11.789	3.908	31.448	**15.715**	4.695
(µg / min)		4.444	1.649	12.023	**6.039**	2.163
ppb	MW = 78.1	3.629	1.203	9.680	**4.837**	1.445
trans-1,3-Dichloropropene						
total µg		<0.021	<0.021	<0.021	**<0.021**	<0.021
(µg / dscm)		<0.387	<0.363	<0.358	**<0.369**	<0.366
(µg / min)		<0.146	<0.153	<0.137	**<0.145**	<0.169
ppb	MW = 111.0	<0.084	<0.079	<0.078	**<0.080**	<0.079
Bromoform						
total µg		<0.036	<0.036	<0.036	**<0.036**	<0.036
(µg / dscm)		<0.663	<0.623	<0.614	**<0.633**	<0.628
(µg / min)		<0.250	<0.263	<0.235	**<0.249**	<0.289
ppb	MW = 252.8	<0.063	<0.059	<0.058	**<0.060**	<0.060
4-Methyl-2-Pentanone						
total µg		<0.057	<0.057	<0.057	**<0.057**	<0.057
(µg / dscm)		<1.050	<0.986	<0.972	**<1.002**	<0.995
(µg / min)		<0.396	<0.416	<0.371	**<0.394**	<0.458
ppb	MW = 100.2	<0.252	<0.236	<0.233	**<0.240**	<0.239

TABLE 7 - cont. (page 4 of 4)

GSS Filter & Catalytic Converter Outlet - RTS #2 Waste Feed Volatile Emissions
EPA Test Method 0030 - VOST

2-Hexanone

total µg		0.223	0.041	<0.093	**0.119**	<0.093
(µg / dscm)		4.108	0.709	<1.585	**2.134**	<1.623
(µg / min)		1.548	0.299	<0.606	**0.818**	<0.748
ppb	MW = 100.2	0.985	0.170	<0.380	**0.512**	<0.389

Tetrachloroethene

total µg		<0.024	<0.024	<0.024	**<0.024**	<0.024
(µg / dscm)		<0.442	<0.415	<0.409	**<0.422**	<0.419
(µg / min)		<0.167	<0.175	<0.156	**<0.166**	<0.193
ppb	MW = 165.8	<0.064	<0.060	<0.059	**<0.061**	<0.061

1,1,2,2-Tetrachloroethane

total µg		<0.042	<0.042	<0.042	**<0.042**	<0.042
(µg / dscm)		<0.774	<0.726	<0.716	**<0.739**	<0.733
(µg / min)		<0.292	<0.306	<0.274	**<0.291**	<0.338
ppb	MW = 167.9	<0.111	<0.104	<0.102	**<0.106**	<0.105

Toluene

total µg		0.208	0.103	0.155	**0.155**	0.44
(µg / dscm)		3.831	1.781	2.642	**2.752**	7.679
(µg / min)		1.444	0.752	1.010	**1.069**	3.538
ppb	MW = 92.1	1.000	0.465	0.690	**0.718**	2.004

Chlorobenzene

total µg		<0.027	<0.027	0.083	**<0.046**	<0.027
(µg / dscm)		<0.497	<0.467	1.415	**<0.793**	<0.471
(µg / min)		<0.187	<0.197	0.541	**<0.308**	<0.217
ppb	MW = 112.6	<0.106	<0.100	0.302	**<0.169**	<0.101

Ethylbenzene

total µg		<0.018	<0.018	<0.018	**<0.018**	0.028
(µg / dscm)		<0.332	<0.311	<0.307	**<0.317**	0.489
(µg / min)		<0.125	<0.131	<0.117	**<0.125**	0.225
ppb	MW = 106.2	<0.075	<0.070	<0.069	**<0.072**	0.111

Stryrene

total µg		0.032	<0.025	<0.026	**<0.028**	<0.024
(µg / dscm)		0.589	<0.432	<0.443	**<0.488**	<0.419
(µg / min)		0.222	<0.182	<0.169	**<0.191**	<0.193
ppb	MW = 104.1	0.136	<0.100	<0.102	**<0.113**	<0.097

Xylene (Total)

total µg		0.061	0.031	0.050	**0.047**	0.168
(µg / dscm)		1.124	0.536	0.852	**0.837**	2.932
(µg / min)		0.424	0.226	0.326	**0.325**	1.351
ppb	MW = 106.2	0.254	0.121	0.193	**0.190**	0.664

1,1,2-Trichlorotrifluoroethane

total µg		<0.600	<0.600	<0.600	**<0.600**	<0.600
(µg / dscm)		<11.052	<10.376	<10.227	**<10.552**	<10.471
(µg / min)		<4.166	<4.378	<3.910	**<4.151**	<4.825
ppb	MW = 187.4	<1.418	<1.331	<1.312	**<1.354**	<1.343

Definitions:

DSCFM = Dry Standard Cubic Feet per Minute

µg / dscm = microgram per dry standard cubic meter

µg / min = emission rate, micrograms per minute

ppb = parts per billion

Calculations:

µg /min = 0.02832 * DSCFM * (µg / dscm)

µg / dscm = total µg / sample vol., dscm

ppb = µg / dscm * 22.4 * (T std. + 460) / 492 / M.W.

T std. = Standard Temperature, °F = 68

TABLE 8
RTS #1 Waste Feed
LLNL Bldg. 292 MSO
GSS Filter & Catalytic Converter Outlets
PARTICULATE& RADIONUCLIDE EMISSIONS TEST RESULTS

RUN #	1	2	3	AVERAGE	Catalyst 1
TEST DATE	8/18/98	8/18/98	8/18/98		08/19/98
TEST TIME	1027-1127	1245-1345	1500-1600		0933-1033
SAMPLE VOLUME (DSCF)	63.313	64.459	62.461		36.296
ISOKINETIC (%)	92.4	96.6	98.8		102.7
DUCT TEMP., (°F)	199.4	236.6	262.8	232.9	401.5
VELOCITY (ft/sec)	32.52	33.61	33.00	33.04	5.28
FLOW RATE (ACFM)	19.51	20.17	19.80	19.83	27.54
FLOW RATE (DSCFM)	14.66	14.27	13.52	14.15	16.61
H_2O (volume %)	3.38	3.89	3.73	3.67	0.90
Gross Alpha (pCi/sample)	5.30	0.24	0.68	2.07	0.55
Gross Beta (pCi/sample)	1.52	1.70	0.50	1.24	0.66
Tritium (pCi/sample)	660.80	540.00	516.60	572.47	75.20
F.H. Particulate Conc. (gr/DSCF)	**0.00003**	**0.0022**	**0.0004**	**0.0009**	**0.0003**
F.H. Particulate Emissions (Lbs/hr)	**0.000003**	**0.00027**	**0.00004**	**0.00011**	**0.00004**
Gross Alpha (pCi/DSCF)	0.084	0.004	0.011	0.03	0.015
Gross Beta (pCi/DSCF)	0.024	0.026	0.008	0.02	0.018
Tritium (pCi/DSCF)	10.44	8.38	8.27	9.03	2.07
Tot. Alpha Emissions (pCi/hr)	**73.63**	**3.19**	**8.83**	**28.549**	**15.11**
Tot. Beta Emissions (pCi/hr)	**21.12**	**22.58**	**6.49**	**16.728**	**18.13**
Tot. Tritium Emissions (pCi/hr)	**9179.8**	**7171.2**	**6709.1**	**7686.7**	**2065.4**

WHERE

DSCF = Sample Volume in Dry Standard Cubic Feet

ACFM = Actual Cubic Feet per Minute

DSCFM = Dry Standard Cubic Feet per Minute

H_2O, volume % = Stack gas percent water vapor

gr/DSCF = Particulate concentration in grains per DSCF

lbs/hr = Particulate emission rate

pCi/hr = Pico Curies per hour emission rate

CALCULATIONS

gr/DSCF = 0.01543 * Sample Wt. / Sample Volume

lbs/hr Emission Rate = 0.00857 * gr/DSCF * DSCFM

pCi/hr = pCi/DSCF * DSCFM * 60

TABLE 9
RTS #2 Waste Feed
LLNL Bldg. 292 MSO
GSS Filter Outlet & Catalytic Converter Outlet
PARTICULATE& RADIONUCLIDE EMISSIONS TEST RESULTS

RUN #	1	2	3	AVERAGE	Catalyst 1
TEST DATE	8/26/98	8/26/98	8/26/98		08/26/98
TEST TIME	0910-1010	1100-1200	1245-1345		1040-1140
SAMPLE VOLUME (DSCF)	42.872	46.501	42.664		33.371
ISOKINETIC (%)	103.1	99.9	101.2		93.4
DUCT TEMP., (°F)	308.4	327.4	335.3	323.7	390.8
VELOCITY (ft/sec)	35.12	39.34	36.31	36.92	5.27
FLOW RATE (ACFM)	21.1	23.6	21.8	22.2	27.5
FLOW RATE (DSCFM)	13.3	14.9	13.5	13.9	16.8
H_2O (volume %)	5.66	3.42	4.26	4.44	0.98
Gross Alpha (pCi/sample)	0.00	0.33	2.12	0.82	0.20
Gross Beta (pCi/sample)	0.00	0.15	0.00	0.05	0.00
Tritium (pCi/sample)	198,764	177,266	188,680	188,237	11,260
F.H. Particulate Conc. (gr/DSCF)	**0.00015**	**0.00017**	**0.00054**	**0.00029**	**0.00007**
F.H. Particulate Emissions (Lbs/hr)	**0.000017**	**0.000022**	**0.000063**	**0.000034**	**0.00001**
Gross Alpha (pCi/DSCF)	0.000	0.007	0.050	0.02	0.006
Gross Beta (pCi/DSCF)	0.000	0.003	0.000	0.001	0.000
Tritium (pCi/DSCF)	4636.17	3812.06	4422.41	4290.22	337.42
Tot. Alpha Emissions (pCi/hr)	**0.000**	**6.345**	**40.242**	**15.529**	**6.04**
Tot. Beta Emissions (pCi/hr)	**0.000**	**2.884**	**0.000**	**0.961**	**0.000**
Tot. Tritium Emissions (pCi/hr)	**3,703,759**	**3,408,472**	**3,581,515**	**3,564,582**	**340,124**

WHERE

DSCF = Sample Volume in Dry Standard Cubic Feet

ACFM = Actual Cubic Feet per Minute

DSCFM = Dry Standard Cubic Feet per Minute

H_2O, volume % = Stack gas percent water vapor

gr/DSCF = Particulate concentration in grains per DSCF

lbs/hr = Particulate emission rate

pCi/hr = Pico Curies per hour emission rate

CALCULATIONS

gr/DSCF = 0.01543 * Sample Wt. / Sample Volume

lbs/hr Emission Rate = 0.00857 * gr/DSCF * DSCFM

pCi/hr = pCi/DSCF * DSCFM * 60

TABLE 10

RTS #1 Waste Feed
LLNL Bldg. 292 MSO
GSS Filter Outlet
Method 0051 HCl Test Results

Test	Run 1	Run 2	Run 3	AVERAGE
Test Date	8/19/98	8/19/98	8/19/98	
Test Time	0915-1015	1025-1125	1131-1231	
Flow Rate (DSCFM)	13.32	13.32	13.32	13.32
Sample Volume (DSCF)	4.024	3.981	3.966	3.990
Sample Volume (DSCM)	0.1139	0.1127	0.1123	0.1130
HCl, (total µg)	<8.00	<8.00	<8.00	<8.00
HCl, (ppm)	<0.046	<0.047	<0.047	<0.047
HCl, (gm/hr)	<0.0016	<0.0016	<0.0016	<0.0016

WHERE:

HCl = Hydrogen Chloride MW = 36.5
DSCM = Dry Standard Cubic Meter
DSCF = Dry Standard Cubic Foot
ppm = Parts Per Million
µg = microgram, = .001 mg (milligram)
gm/hr = Grams per Hour Emission Rate
< = Less Than the Reporting Limit
Std. Temperature, Tstd °F = **68**

CALCULATIONS:

ppm = ug/sample * 1.61 * (Tstd + 460) / (MW*DSCF*1000)
gm/hr = 453.6 *ppm * M.W. * DSCFM * 8.223E-5 / (Tstd + 460)

TABLE 11

RTS #2 Waste Feed
LLNL Bldg. 292 MSO
GSS Filter Outlet
Method 0051 HCl Test Results

Test	Run 1	Run 2	Run 3	AVERAGE
Test Date	8/26/98	8/26/98	8/26/98	
Test Time	1519-1619	1637-1747	1808-1908	
Flow Rate (DSCFM)	12.99	13.96	13.96	13.64
Sample Volume (DSCF)	4.225	4.896	4.066	4.396
Sample Volume (DSCM)	0.1196	0.1386	0.1151	0.1245
HCl, (total µg)	<8.00	<8.00	<8.00	<8.00
HCl, (ppm)	<0.044	<0.038	<0.046	<0.043
HCl, (gm/hr)	<0.0015	<0.0014	<0.0016	<0.0015

WHERE:

HCl = Hydrogen Chloride MW = 36.5
DSCM = Dry Standard Cubic Meter
DSCF = Dry Standard Cubic Foot
ppm = Parts Per Million
µg = microgram, = .001 mg (milligram)
gm/hr = Grams per Hour Emission Rate
< = Less Than the Reporting Limit
Standard Temperature, Tstd °F **68**

CALCULATIONS:

ppm = ug/sample * 1.61 * (Tstd + 460) / (MW*DSCF*1000)
gm/hr = 453.6 *ppm * M.W. * DSCFM * 8.223E-5 / (Tstd + 460)

APPENDICES

APPENDIX A – CALCULATIONS & NOMENCLATURE

APPENDIX B - LABORATORY REPORTS

APPENDIX C - FIELD DATA SHEETS

APPENDIX D- EQUIPMENT CALIBRATION RECORDS

APPENDIX E - PROCESS DATA

APPENDIX F – STACK DIAGRAMS

APPENDIX G – SAMPLING SYSTEM DIAGRAMS

APPENDIX A
CALCULATIONS & NOMENCLATURE

Standard Abbreviations for Reports

Unit	Abbreviation	Unit	Abbreviation
billion	G	microgram	µg
Brake horsepower	bhp	milligram	mg
Brake horsepower hour	bhp-hr	milliliter	ml
British Thermal Unit	Btu	million	MM
capture efficiency	CE	minute	min
destruction efficiency	DE	Molecular Weight	MW
Dry Standard Cubic Feet	DSCF	nanogram	ng
Dry Standard Cubic Feet per Minute	DSCFM	Parts per Billion	ppb
Dry Standard Cubic Meter	DSCM	Parts per Million	ppm
Dry Standard Cubic Meter per Minute	DSCMM	pennyweight per firkin	pw/fkn
grains per dry standard cubic foot	gr/DSCF	pound	lb
gram	g	pounds per hour	lbs/hr
grams per Brake horsepower hour	g/bhp-hr	pounds per million Btu	lbs/MMBtu
kilowatt	kw	second	sec
liter	l	thousand	k
Megawatts	mw	watt	w
meter	m		

Common Conversions / Calculations / Constants

1 gram = 15.432 grains

1 pound = 7000 grains

grams per pound = 453.6

bhp = kw * 1.34

2.59E-9 = Conversion factor for ppm to lbs/scf; **EPA 40CFR60.45**

dscf / MMBTU = 8710 for Natural gas; **EPA Method 19**

Btu/ft^3 = 1040 for Naural Gas; **EPA Method 19**

lb/hr Part. Emission Rate = 0.00857 * gr/dscf * dscfm; **EPA Method 5**

g/bhp-hr = lbs/hr * 453.6 / bhp

lbs/hr = ppm / 385 E^6 x dscfm x MW * 60; **CARB Method 100**

Correction to 12% CO_2 = gr/dscf * 12% / stack CO_2%; **EPA Method 5**

Correction to 3% O_2 = ppm * 17.9 / (20.9 - stack O_2 %); CARB Method 100

dscfm = Gas Fd * MMBtu/min * 20.9 / (20.9 - stack O_2 %); EPA Method 19

lb/MMBtu = Fd * MW * ppm * 2.59E-9 * 20.9 / (20.9 - stack O_2 %); EPA Method 19

Standard Temperatures by District

EPA	68 °F	NSAPCD - Northern Sonoma	68 °F
CARB	68 °F	PCAPCD - Placer	68 °F
BAAQMD - Bay Area	70 °F	SLOCAPCD - San Luis Obispo	60 °F
SJVUAPCD - San Joaquin	60 °F	SMAPCD - Sacramento	59 °F → 68°F
SCAQMD - South Coast	60 °F	SCAQMD - Shasta County	68 °F
MBUAPCD - Monterey Bay	60 °F	YSAPCD - Yolo-Solano	68 °F

EPA 23 EMISSION CALCULATIONS

FACILITY:	LLNL Bldg. 292	DATE:	8/18/98	METER BOX NO.:	LSI-2
UNIT:	GSS Filter Inlet	TIME:	1016-1326	PROBE NO.:	N.A.
CONDITION:	RTS #1 Waste Feed	TEST NO.:	1	NOZZLE NO.:	5E

Pitot Factor,	C_p	0.990	Meter Temperature,	T_m	85.6	Total H_2O Condensed,	V_w	119.0
Barometric Pressure,	P_b	30.00	Meter Pressure,	ΔH	1.70			
Static Pressure,	P_{stat}	-11.50	Average $\sqrt{\Delta P}$,	$\sqrt{\Delta P}$	0.441			
Stack Pressure,	P_s	29.15	Stack Area,	A_s	0.010			
Stack Temperature,	T_s	292.5	Nozzle Diameter,	D_n	0.309	Stack Gas O_2	%	12.4
Sample Time,	Θ	180.0	Meter Factor,	Y_d	1.0089	Stack Gas CO_2	%	7.90
Std. Temperature,	T_{std}	68	Sample Volume,	V_m	106.278	Stack Gas N_2	%	79.7

A) Gas Volume $(V_m)_{std} = (T_{std}+460)*V_m*Y_d*(P_b+\Delta H/13.6)/((T_m+460)*29.92) =$ 104.476 DSCF

B) Volume H_2O collected $(V_w)_{std} = 8.9148E\text{-}5*(T_{std}+460)*V_w =$ 5.601 SCF

C) Total Sample Volume $(V_t)_{std} = (V_m)_{std} + (V_w)_{std} =$ 110.077 SCF

D) Moisture Content $(\%H_2O) = 100 * (V_w)_{std} / (V_t)_{std} =$ 5.089 %

E) Stack Gas Velocity $(Vs) = 85.49\ C_p\ \sqrt{(\Delta P)}\ (T_s + 460/MW_s\ P_s) =$ 35.114 ft/sec

F) Stack Gas Molecular Wt.$= ((CO_2\%*0.44+O_2\%*0.32+N_2\%*0.28)(1-H_2O\%/100))+18(H_2O\%/100) =$ 29.162 g/g-mole

G) % Isokinetic $(I) = 9142.88(V_t)(T_s+460)/((D_n^2)(\Theta)(P_s)(V_s)(T_{std}+460)) =$ 81.52 %

H) $ACFM = (V_s)(A_s) \times 60 =$ 21.07 ACFM

I) Stack Gas Vol. Flow Rate, $DSCFM = (V_s)(A_s)((T_{std}+460)/(T_s+460))(P_s)(1-\%H_2O/100)*2.005 =$ 13.67 DSCFM

EPA 23 EMISSION CALCULATIONS

FACILITY:	LLNL Bldg. 292	DATE:	8/18/98	METER BOX NO.:	LSI-2
UNIT:	GSS Filter Inlet	TIME:	1413-1707	PROBE NO.:	N.A.
CONDITION:	RTS #1 Waste Feed	TEST NO.:	2	NOZZLE NO.:	5E

Pitot Factor,	C_p	0.990	Meter Temperature,	T_m	88.7	Total H_2O Condensed,	V_w	132.0
Barometric Pressure,	P_b	30.00	Meter Pressure,	ΔH	1.62			
Static Pressure,	P_{stat}	-11.50	Average $\sqrt{\Delta P}$.,	$\sqrt{\Delta P}$	0.448			
Stack Pressure,	P_s	29.15	Stack Area,	A_s	0.010			
Stack Temperature,	T_s	351.0	Nozzle Diameter,	D_n	0.309	Stack Gas O_2	%	10.0
Sample Time,	Θ	180.0	Meter Factor,	Y_d	1.0089	Stack Gas CO_2	%	9.60
Std. Temperature,	T_{std}	68	Sample Volume,	V_m	119.167	Stack Gas N_2	%	80.4

A) Gas Volume $(V_m)_{std} = (T_{std}+460)*V_m*Y_d*(P_b+\Delta H/13.6)/((T_m+460)*29.92) =$ 116.462 DSCF

B) Volume H_2O collected $(V_w)_{std} = 8.9148E\text{-}5*(T_{std}+460)*V_w =$ 6.213 SCF

C) Total Sample Volume $(V_t)_{std} = (V_m)_{std} + (V_w)_{std} =$ 122.675 SCF

D) Moisture Content $(\%H_2O) = 100 * (V_w)_{std} / (V_t)_{std} =$ 5.065 %

E) Stack Gas Velocity $(Vs) = 85.49\ C_p \sqrt{(\Delta P)}\ (T_s + 460/MW_s\ P_s) =$ 36.925 ft/sec

F) Stack Gas Molecular Wt.$= ((CO_2\%*0.44+O_2\%*0.32+N_2\%*0.28)(1-H_2O\%/100))+18(H_2O\%/100) =$ 29.331 g/g-mole

G) % Isokinetic $(I) = 9142.88(V_t)(T_s+460)/((D_n^2)(\Theta)(P_s)(V_s)(T_{std}+460)) =$ 93.11 %

H) ACFM $= (V_s)(A_s) \times 60 =$ 22.15 ACFM

I) Stack Gas Vol. Flow Rate, DSCFM $= (V_s)(A_s)((T_{std}+460)/(T_s+460))(P_s)(1-\%H_2O/100)*2.005 =$ 13.34 DSCFM

EPA 23 EMISSION CALCULATIONS

FACILITY:	LLNL Bldg. 292	DATE:	8/19/98	METER BOX NO.:	LSI-2
UNIT:	GSS Filter Inlet	TIME:	0918-1308	PROBE NO.:	N.A.
CONDITION:	RTS #1 Waste Feed	TEST NO.:	3	NOZZLE NO.:	5E

Pitot Factor,	C_p	0.990	Meter Temperature,	T_m	81.4	Total H_2O Condensed,	V_w	112.5
Barometric Pressure,	P_b	29.90	Meter Pressure,	ΔH	1.86			
Static Pressure,	P_{stat}	-11.50	Average $\sqrt{\Delta P}$.,	$\sqrt{\Delta P}$	0.437			
Stack Pressure,	P_s	29.05	Stack Area,	A_s	0.010			
Stack Temperature,	T_s	317.9	Nozzle Diameter,	D_n	0.309	Stack Gas O_2	%	9.34
Sample Time,	Θ	180.0	Meter Factor,	Y_d	1.0089	Stack Gas CO_2	%	10.15
Std. Temperature,	T_{std}	68	Sample Volume,	V_m	114.898	Stack Gas N_2	%	80.5

A) Gas Volume $(V_m)_{std} = (T_{std}+460)*V_m*Y_d*(P_b+\Delta H/13.6)/((T_m+460)*29.92) =$ 113.493 DSCF

B) Volume H_2O collected $(V_w)_{std} = 8.9148E\text{-}5*(T_{std}+460)*V_w =$ 5.295 SCF

C) Total Sample Volume $(V_t)_{std} = (V_m)_{std} + (V_w)_{std} =$ 118.788 SCF

D) Moisture Content $(\%H_2O) = 100 * (V_w)_{std} / (V_t)_{std} =$ 4.458 %

E) Stack Gas Velocity $(Vs) = 85.49\ C_p \sqrt{(\Delta P)}\ (T_s + 460/MW_s\ P_s) =$ 35.257 ft/sec

F) Stack Gas Molecular Wt.$= ((CO_2\%*0.44+O_2\%*0.32+N_2\%*0.28)(1-H_2O\%/100))+18(H_2O\%/100) =$ 29.463 g/g-mole

G) % Isokinetic $(I) = 9142.88(V_t)(T_s+460)/((D_n^2)(\Theta)(P_s)(V_s)(T_{std}+460)) =$ 90.89 %

H) ACFM $= (V_s)(A_s) \times 60 =$ 21.15 ACFM

I) Stack Gas Vol. Flow Rate, DSCFM $= (V_s)(A_s)((T_{std}+460)/(T_s+460))(P_s)(1-\%H_2O/100)*2.005 =$ 13.32 DSCFM

EPA 23 EMISSION CALCULATIONS

FACILITY:	LLNL Bldg. 292	DATE:	8/18/98	METER BOX NO.:	LSI-1
UNIT:	Catalyst Outlet	TIME:	1428-1726	PROBE NO.:	N.A.
CONDITION:	RTS #1 Waste Feed	TEST NO.:	1	NOZZLE NO.:	1

Pitot Factor,	C_p	0.990	Meter Temperature,	T_m	104.4	Total H_2O Condensed,	V_w	80.0
Barometric Pressure,	P_b	29.90	Meter Pressure,	ΔH	3.00			
Static Pressure,	P_{stat}	-2.50	Average $\sqrt{\Delta P}$.,	$\sqrt{\Delta P}$	0.063			
Stack Pressure,	P_s	29.72	Stack Area,	A_s	0.087			
Stack Temperature,	T_s	390.0	Nozzle Diameter,	D_n	0.971	Stack Gas O_2,	%	8.8
Sample Time,	Θ	180.0	Meter Factor,	Y_d	1.0039	Stack Gas CO_2,	%	10.50
Std. Temperature,	T_{std}	68	Sample Volume,	V_m	160.435	Stack Gas N_2,	%	80.7

A) Gas Volume $(V_m)_{std} = (T_{std}+460)*V_m*Y_d*(P_b+\Delta H/13.6)/((T_m+460)*29.92) =$ 151.684 DSCF

B) Volume H_2O collected $(V_w)_{std} = 8.9148E\text{-}5*(T_{std}+460)*V_w =$ 3.766 SCF

C) Total Sample Volume $(V_t)_{std} = (V_m)_{std} + (V_w)_{std} =$ 155.449 SCF

D) Moisture Content $(\%H_2O) = 100 * (V_w)_{std} / (V_t)_{std} =$ 2.422 %

E) Stack Gas Velocity $(Vs) = 85.49\ C_p \sqrt{(\Delta P)}\ (T_s + 460/MW_s\ P_s) =$ 5.246 ft/sec

F) Stack Gas Molecular Wt.$= ((CO_2\%*0.44+O_2\%*0.32+N_2\%*0.28)(1-H_2O\%/100))+18(H_2O\%/100) =$ 29.741 g/g-mole

G) % Isokinetic $(I) = 9142.88(V_t)(T_s+460)/((D_n^2)(\Theta)(P_s)(V_s)(T_{std}+460)) =$ 86.49 %

H) $ACFM = (V_s)(A_s) \times 60 =$ 27.38 ACFM

I) Stack Gas Vol. Flow Rate, $DSCFM = (V_s)(A_s)(T_{std}+460)/(T_s+460)(P_s)(1-\%H_2O/100)*2.005 =$ 16.48 DSCFM

EPA 23 EMISSION CALCULATIONS

FACILITY:	LLNL Bldg. 292	DATE:	8/26/98	METER BOX NO.:	LSI-2
UNIT:	GSS Filter Inlet	TIME:	0903-1216	PROBE NO.:	N.A.
CONDITION:	RTS#2 Waste Feed	TEST NO.:	1	NOZZLE NO.:	Q5A

Pitot Factor,	C_p	0.990	Meter Temperature,	T_m	84.4	Total H_2O Condensed,	V_w	112.5
Barometric Pressure,	P_b	29.90	Meter Pressure,	ΔH	2.77			
Static Pressure,	P_{stat}	-10.00	Average $\sqrt{\Delta P}$,	$\sqrt{\Delta P}$	0.466			
Stack Pressure,	P_s	29.16	Stack Area,	A_s	0.010			
Stack Temperature,	T_s	320.6	Nozzle Diameter,	D_n	0.326	Stack Gas O_2	%	10.36
Sample Time,	Θ	180.0	Meter Factor,	Y_d	1.0089	Stack Gas CO_2	%	7.46
Std. Temperature,	T_{std}	68	Sample Volume,	V_m	160.670	Stack Gas N_2	%	82.2

A) Gas Volume $(V_m)_{std} = (T_{std}+460)*V_m*Y_d*(P_b+\Delta H/13.6)/((T_m+460)*29.92) =$ 158.170 DSCF

B) Volume H_2O collected $(V_w)_{std} = 8.9148E\text{-}5*(T_{std}+460)*V_w =$ 5.295 SCF

C) Total Sample Volume $(V_t)_{std} = (V_m)_{std} + (V_w)_{std} =$ 163.466 SCF

D) Moisture Content $(\%H_2O) = 100 * (V_w)_{std} / (V_t)_{std} =$ 3.239 %

E) Stack Gas Velocity $(Vs) = 85.49 \cdot C_p \sqrt{(\Delta P)} (T_s + 460/MW_s P_s) =$ 37.739 ft/sec

F) Stack Gas Molecular Wt.$= ((CO_2\%*0.44+O_2\%*0.32+N_2\%*0.28)(1-H_2O\%/100))+18(H_2O\%/100) =$ 29.232 g/g-mole

G) % Isokinetic (I) $= 9142.88(V_t)(T_s+460)/((D_n^2)(\Theta)(P_s)(V_s)(T_{std}+460)) =$ 104.94 %

H) ACFM $= (V_s)(A_s) \times 60 =$ 22.64 ACFM

I) Stack Gas Vol. Flow Rate, DSCFM $= (V_s)(A_s)((T_{std}+460)/(T_s+460))(P_s)(1-\%H_2O/100)*2.005 =$ 14.45 DSCFM

EPA 23 EMISSION CALCULATIONS

FACILITY:	LLNL Bldg. 292	DATE:	8/26/98	METER BOX NO.:	LSI-2
UNIT:	GSS Filter Inlet	TIME:	1309-1616	PROBE NO.:	N.A.
CONDITION:	RTS#2 Waste Feed	TEST NO.:	2	NOZZLE NO.:	5B

Pitot Factor,	C_p	0.990	Meter Temperature,	T_m	86.4	Total H_2O Condensed,	V_w	154.0
Barometric Pressure,	P_b	29.90	Meter Pressure,	ΔH	1.97			
Static Pressure,	P_{stat}	-10.00	Average $\sqrt{\Delta P}$.,	$\sqrt{\Delta P}$	0.432			
Stack Pressure,	P_s	29.16	Stack Area,	A_s	0.010			
Stack Temperature,	T_s	340.5	Nozzle Diameter,	D_n	0.304	Stack Gas O_2	%	10.0
Sample Time,	Θ	180.0	Meter Factor,	Y_d	1.0089	Stack Gas CO_2	%	7.30
Std. Temperature,	T_{std}	68	Sample Volume,	V_m	128.801	Stack Gas N_2	%	82.7

A) Gas Volume $(V_m)_{std} = (T_{std}+460)*V_m*Y_d*(P_b+\Delta H/13.6)/((T_m+460)*29.92)$ = 126.098 DSCF

B) Volume H_2O collected $(V_w)_{std} = 8.9148E\text{-}5*(T_{std}+460)*V_w$ = 7.249 SCF

C) Total Sample Volume $(V_t)_{std} = (V_m)_{std} + (V_w)_{std}$ = 133.346 SCF

D) Moisture Content $(\%H_2O) = 100 * (V_w)_{std} / (V_t)_{std}$ = 5.436 %

E) Stack Gas Velocity $(Vs) = 85.49\ C_p\ \sqrt{(\Delta P)}\ (T_s + 460/MW_s\ P_s)$ = 35.608 ft/sec

F) Stack Gas Molecular Wt.= $((CO_2\%*0.44+O_2\%*0.32+N_2\%*0.28)(1-H_2O\%/100))+18(H_2O\%/100)$ = 28.939 g/g-mole

G) % Isokinetic $(I) = 9142.88(V_t)(T_s+460)/((D_n^2)(\Theta)(P_s)(V_s)(T_{std}+460))$ = 107.00 %

H) ACFM $= (V_s)(A_s) \times 60$ = 21.36 ACFM

I) Stack Gas Vol. Flow Rate, DSCFM $= (V_s)(A_s)((T_{std}+460)/(T_s+460))(P_s)(1-\%H_2O/100)*2.005$ = 12.99 DSCFM

ON

EPA 23 EMISSION CALCULATIONS

FACILITY:	LLNL Bldg. 292	DATE:	8/26/98	METER BOX NO.:	LSI-2
UNIT:	GSS Filter Inlet	TIME:	1636-2002	PROBE NO.:	N.A.
CONDITION:	RTS#2 Waste Feed	TEST NO.:	3	NOZZLE NO.:	5B

Pitot Factor,	C_p	0.990	Meter Temperature,	T_m	84.1	Total H_2O Condensed,	V_w	136.0
Barometric Pressure,	P_b	29.90	Meter Pressure,	ΔH	1.93			
Static Pressure,	P_{stat}	-10.00	Average $\sqrt{\Delta P}$.,	$\sqrt{\Delta P}$	0.450			
Stack Pressure,	P_s	29.16	Stack Area,	A_s	0.010			
Stack Temperature,	T_s	292.1	Nozzle Diameter,	D_n	0.304	Stack Gas O_2	%	10.01
Sample Time,	Θ	180.0	Meter Factor,	Y_d	1.0089	Stack Gas CO_2	%	7.29
Std. Temperature,	T_{std}	68	Sample Volume,	V_m	114.124	Stack Gas N_2	%	82.7

A) Gas Volume $(V_m)_{std} = (T_{std}+460)*V_m*Y_d*(P_b+\Delta H/13.6)/((T_m+460)*29.92) =$ 112.188 DSCF

B) Volume H_2O collected $(V_w)_{std} = 8.9148E\text{-}5*(T_{std}+460)*V_w =$ 6.402 SCF

C) Total Sample Volume $(V_t)_{std} = (V_m)_{std} + (V_w)_{std} =$ 118.589 SCF

D) Moisture Content $(\%H_2O) = 100 * (V_w)_{std} / (V_t)_{std} =$ 5.398 %

E) Stack Gas Velocity $(Vs) = 85.49\ C_p\ \sqrt{(\Delta P)}\ (T_s + 460/MW_s\ P_s) =$ 35.950 ft/sec

F) Stack Gas Molecular Wt.$= ((CO_2\%*0.44+O_2\%*0.32+N_2\%*0.28)(1-H_2O\%/100))+18(H_2O\%/100) =$ 28.942 g/g-mole

G) % Isokinetic $(I) = 9142.88(V_t)(T_s+460)/((D_n^2)(\Theta)(P_s)(V_s)(T_{std}+460)) =$ 88.55 %

H) $ACFM = (V_s)(A_s) \times 60 =$ 21.57 ACFM

I) Stack Gas Vol. Flow Rate, $DSCFM = (V_s)(A_s)((T_{std}+460)/(T_s+460))(P_s)(1-\%H_2O/100)*2.005 =$ 13.96 DSCFM

EPA 23 EMISSION CALCULATIONS

FACILITY:	LLNL Bldg. 292	DATE:	8/26/98	METER BOX NO.:	LSI-1
UNIT:	Catalyst Outlet	TIME:	1210-1510	PROBE NO.:	N.A.
CONDITION:	RTS #2 Waste Feed	TEST NO.:	1	NOZZLE NO.:	1

Pitot Factor,	C_p	0.990	Meter Temperature,	T_m	108.6	Total H_2O Condensed,	V_w	123.0
Barometric Pressure,	P_b	29.99	Meter Pressure,	ΔH	3.00			
Static Pressure,	P_{stat}	-2.50	Average $\sqrt{\Delta P}$.,	$\sqrt{\Delta P}$	0.063			
Stack Pressure,	P_s	29.81	Stack Area,	A_s	0.087			
Stack Temperature,	T_s	390.0	Nozzle Diameter,	D_n	0.971	Stack Gas O_2,	%	8.8
Sample Time,	Θ	180.0	Meter Factor,	Y_d	1.0039	Stack Gas CO_2,	%	10.50
Std. Temperature,	T_{std}	68	Sample Volume,	V_m	141.126	Stack Gas N_2,	%	80.7

A) Gas Volume $(V_m)_{std} = (T_{std}+460)*V_m*Y_d*(P_b+\Delta H/13.6)/((T_m+460)*29.92) =$ 132.838 DSCF

B) Volume H_2O collected $(V_w)_{std} = 8.9148E\text{-}5*(T_{std}+460)*V_w =$ 5.790 SCF

C) Total Sample Volume $(V_t)_{std} = (V_m)_{std} + (V_w)_{std} =$ 138.628 SCF

D) Moisture Content $(\%H_2O) = 100 * (V_w)_{std} / (V_t)_{std} =$ 4.176 %

E) Stack Gas Velocity $(Vs) = 85.49\ C_p \sqrt{(\Delta P)}\ (T_s + 460/MW_s\ P_s) =$ 5.256 ft/sec

F) Stack Gas Molecular Wt.$= ((CO_2\%*0.44+O_2\%*0.32+N_2\%*0.28)(1-H_2O\%/100))+18(H_2O\%/100) =$ 29.529 g/g-mole

G) % Isokinetic $(I) = 9142.88(V_t)(T_s+460)/((D_n^2)(\Theta)(P_s)(V_s)(T_{std}+460)) =$ 76.74 %

H) $ACFM = (V_s)(A_s) \times 60 =$ 27.44 ACFM

I) Stack Gas Vol. Flow Rate, $DSCFM = (V_s)(A_s)((T_{std}+460)/(T_s+460))(P_s)(1-\%H_2O/100)*2.005 =$ 16.27 DSCFM

Volume Correction Calculations
EPA Method 0030-VOST

Meter # : 2400
Meter factor 0.9818

RTS #1 Waste Feed

Run #	#1-GSS Out	#2-GSS Out	#3-GSS Out	#1-Cat. Out
Date	8/18/98	8/18/98	8/18/98	8/18/98
Time	1059-1215	1234-1350	1424-1546	1614-1740
Barometric Pressure	29.9	29.9	29.9	29.9
Raw Sample Volume, liters	59.0	55.7	56.3	61.1
Meter Temp, °F (avg)	76.30	77.70	77.30	79.60
Corrected Volume, liters	57.02	53.69	54.31	58.69
Corrected Volume, meters	0.057	0.054	0.054	0.059

Volume Correction Calculations
EPA Method 0030-VOST

Meter # : 2400
Meter factor 0.9818

RTS #2 Waste Feed

Run #	#1-GSS Out	#2-GSS Out	#3-GSS Out	#1-Cat. Out
Date	8/26/98	8/26/98	8/26/98	8/26/98
Time	0903-1024	1048-1210	1229-1348	1410-1530
Barometric Pressure	29.9	29.9	29.9	29.9
Raw Sample Volume, liters	56.1	60.1	61	59.7
Meter Temp, °F (avg)	75.60	78.70	78.90	80.00
Corrected Volume, liters	54.29	57.82	58.67	57.30
Corrected Volume, meters	0.054	0.058	0.059	0.057

EPA 17/114 PARTICULATE & RADIONUCLIDE EMISSION CALCULATIONS

FACILITY:	LLNL Bldg. 292 MSO	DATE:	8/18/98	METER BOX NO.:	ASI 8
UNIT:	GSS Filter Outlet	TIME:	1027-1127	PROBE NO.:	N.A.
CONDITION:	RTS #1 Waste Feed	TEST NO.:	1	NOZZLE NO.:	6A

Pitot Factor,	C_p	0.990	Meter Temp., °F	T_m	81.1	Total H_2O Condensed,	V_w	47.1
Barometric Press., "Hg	P_b	29.90	Meter Press.,"H_2O	ΔH	3.660	Total F.H. Particulate,	mg	0.11
Static Pressure, "H_2O	P_{stat}	-11.50	Average $\sqrt{\Delta P}$., "H_2O	$\sqrt{\Delta P}$	0.437	B.H. Organics,	mg	N.A.
Stack Pressure, "Hg	P_s	29.05	Stack Area, Ft^2	A_s	0.010	B.H. Inorganics,	mg	N.A.
Stack Temp., °F	T_s	199.4	Nozzle Dia., Inches	D_n	0.378	Stack Gas O_2,	O_2 %	11.8
Sample Time, mins	Θ	60	Meter Factor,	Y_d	0.9593	Stack Gas CO_2,	CO_2 %	8.00
Std. Temp., °F	T_{std}	68	Sample Volume, Ft^3	V_m	67.078	Stack Gas N_2,	N_2 %	80.2

A) Sample Volume $(V_m)_{std} = (T_{std}+460)*V_m*Y_d*(P_b+\Delta H/13.6)/((T_m+460)*29.92)$ = 63.313 DSCF

B) Volume H_2O collected $(V_w)_{std} = 8.9148E\text{-}5*(T_{std}+460)*V_w$ = 2.217 SCF

C) Total Sample Volume $(V_t)_{std} = (V_m)_{std} + (V_w)_{std}$ = 65.530 SCF

D) Moisture Content $(\%H_2O) = 100 * (V_w)_{std} / (V_t)_{std}$ = 3.4 %

E) Stack Gas Velocity (Vs) = $85.49\ C_p\ \sqrt{(\Delta P)}\ (T_s + 460/MW_s\ P_s)$ = 32.52 ft/sec

F) Stack Gas Molecular Wt.= $((CO_2\%*0.44+O_2\%*0.32+N_2\%*0.28)(1-H_2O\%/100))+18(H_2O\%/100)$ = 29.35 g/gm-mole

G) % Isokinetic (I) = $9142.88(V_t)(T_s+460)/((D_n^2)(\Theta)(P_s)(V_s)(T_{std}+460))$ = 92.37 %

H) ACFM = $(V_s)(A_s)60$ = 19.51 ACFM

I) Stack Gas Vol. Flow Rate, DSCFM = $(V_s)(A_s)((T_{std}+460)/(T_s+460))(P_s)(1-\%H_2O/100)*2.005$ = 14.66 DSCFM

J) F.H. Particulate Concentration (gr/DSCF) = mg/Vmstd * 0.01543 = 0.00003 gr/DSCF

K) F.H. Particulate Emission Rate = 0.00857 * gr/DSCF * DSCFM = 0.000003 lbs/hr

000000

EPA 17/114 PARTICULATE & RADIONUCLIDE EMISSION CALCULATIONS

FACILITY:	LLNL Bldg. 292 MSO	DATE:	8/18/98	METER BOX NO.:	ASI 8
UNIT:	GSS Filter Outlet	TIME:	1245-1345	PROBE NO.:	N.A.
CONDITION:	RTS #1 Waste Feed	TEST NO.:	2	NOZZLE NO.:	6A

Pitot Factor,	C_p	0.99	Meter Temp., °F	T_m	85.5	Total H_2O Condensed,	V_w	55.4
Barometric Press., "Hg	P_b	29.90	Meter Press.,"H_2O	ΔH	3.820	Total F.H. Particulate,	mg	9.20
Static Pressure, "H_2O	P_{stat}	-11.50	Average $\sqrt{\Delta P}$., "H_2O	$\sqrt{\Delta P}$	0.439	B.H. Organics,	mg	N.A.
Stack Pressure, "Hg	P_s	29.05	Stack Area, Ft^2	A_s	0.010	B.H. Inorganics,	mg	N.A.
Stack Temp., °F	T_s	236.6	Nozzle Dia., Inches	D_n	0.378	Stack Gas O_2	O_2 %	11.8
Sample Time, mins	Θ	60.0	Meter Factor,	Y_d	0.9593	Stack Gas CO_2	CO_2 %	8.00
Std. Temp., °F	T_{std}	68	Sample Volume, Ft^3	V_m	68.821	Stack Gas N_2	N_2 %	80.2

A) Sample Volume $(V_m)_{std} = (T_{std}+460)*V_m*Y_d*(P_b+\Delta H/13.6)/((T_m+460)*29.92) =$ 64.459 DSCF

B) Volume H_2O collected $(V_w)_{std} = 8.9148E\text{-}5*(T_{std}+460)*V_w =$ 2.608 SCF

C) Total Sample Volume $(V_t)_{std} = (V_m)_{std} + (V_w)_{std} =$ 67.067 SCF

D) Moisture Content $(\%H_2O) = 100 * (V_w)_{std} / (V_t)_{std} =$ 3.9 %

E) Stack Gas Velocity (Vs) $= 85.49\ C_p\ \sqrt{(\Delta P)}\ (T_s + 460/MW_s\ P_s) =$ 33.61 ft/sec

F) Stack Gas Molecular Wt.$= ((CO_2\%*0.44+O_2\%*0.32+N_2\%*0.28)(1-H_2O\%/100))+18(H_2O\%/100) =$ 29.30 g/gm-mole

G) % Isokinetic (I) $= 9142.88(V_t)(T_s+460)/((D_n^2)(\Theta)(P_s)(V_s)(T_{std}+460)) =$ 96.63 %

H) ACFM $= (V_s)(A_s)60 =$ 20.17 ACFM

I) Stack Gas Vol. Flow Rate, DSCFM $= (V_s)(A_s)((T_{std}+460)/(T_s+460))(P_s)(1-\%H_2O/100)*2.005 =$ 14.27 DSCFM

J) F.H. Particulate Concentration (gr/DSCF) = mg/Vmstd * 0.01543 = 0.0022 gr/DSCF

K) F.H. Particulate Emission Rate = 0.00857 * gr/DSCF * DSCFM = 0.000269 Lbs/hr

EPA 17/114 PARTICULATE & RADIONUCLIDE EMISSION CALCULATIONS

FACILITY:	LLNL Bldg. 292 MSO	DATE:	8/18/98	METER BOX NO.:	ASI 8
UNIT:	GSS Filter Outlet	TIME:	1500-1600	PROBE NO.:	N.A.
CONDITION:	RTS #1 Waste Feed	TEST NO.:	3	NOZZLE NO.:	6A

Pitot Factor,	C_p	0.990	Meter Temp., °F	T_m	85.6	Total H_2O Condensed,	V_w	51.4
Barometric Press., "Hg	P_b	29.90	Meter Press.,"H_2O	ΔH	3.500	Total F.H. Particulate,	mg	1.50
Static Pressure, "H_2O	P_{stat}	-11.50	Average $\sqrt{\Delta P}$., "H_2O	$\sqrt{\Delta P}$	0.423	B.H. Organics,	mg	N.A.
Stack Pressure, "Hg	P_s	29.05	Stack Area, Ft^2	A_s	0.010	B.H. Inorganics,	mg	N.A.
Stack Temp., °F	T_s	262.8	Nozzle Dia., Inches	D_n	0.378	Stack Gas O_2	O_2 %	11.9
Sample Time, mins	Θ	60.0	Meter Factor,	Y_d	0.9593	Stack Gas CO_2	CO_2 %	7.80
Std. Temp., °F	T_{std}	68	Sample Volume, Ft^3	V_m	66.752	Stack Gas N_2	N_2 %	80.3

A) Gas Volume $(V_m)_{std} = (T_{std}+460)*V_m*Y_d*(P_b+\Delta H/13.6)/((T_m+460)*29.92) =$ 62.461 DSCF

B) Volume H_2O collected $(V_w)_{std} = 8.9148E\text{-}5*(T_{std}+460)*V_w =$ 2.419 SCF

C) Total Sample Volume $(V_t)_{std} = (V_m)_{std} + (V_w)_{std} =$ 64.881 SCF

D) Moisture Content $(\%H_2O) = 100 * (V_w)_{std} / (V_t)_{std} =$ 3.7 %

E) Stack Gas Velocity $(Vs) = 85.49\ C_p\ \sqrt{(\Delta P)}\ (T_s + 460/MW_s\ P_s) =$ 33.00 ft/sec

F) Stack Gas Molecular Wt.$= ((CO_2\%*0.44+O_2\%*0.32+N_2\%*0.28)(1-H_2O\%/100))+18(H_2O\%/100) =$ 29.29 g/gm-mole

G) % Isokinetic (I) $= 9142.88(V_t)(T_s+460)/((D_n^2)(\Theta)(P_s)(V_s)(T_{std}+460)) =$ 98.80 %

H) $ACFM = (V_s)(A_s)60 =$ 19.80 ACFM

I) Stack Gas Vol. Flow Rate, $DSCFM = (V_s)(A_s)((T_{std}+460)/(T_s+460))(P_s)(1-\%H_2O/100)*2.005 =$ 13.52 DSCFM

J) F.H. Particulate Concentration (gr/DSCF) = mg/Vmstd * 0.01543 = 0.0004 gr/DSCF

K) F.H. Particulate Emission Rate = 0.00857 * gr/DSCF * DSCFM = 0.000043 Lbs/hr

EPA 17/114 PARTICULATE & RADIONUCLIDE EMISSION CALCULATIONS

FACILITY:	LLNL Bldg. 292 MSO	DATE:	8/19/98	METER BOX NO.:	LSI 1
UNIT:	GSS Filter Outlet	TIME:	0933-1033	PROBE NO.:	N.A.
CONDITION:	Normal	TEST NO.:	Catalyst Outlet	NOZZLE NO.:	41

Pitot Factor,	C_p	0.990	Meter Temp., °F	T_m	96.4	Total H_2O Condensed,	V_w	7.0
Barometric Press., "Hg	P_b	29.90	Meter Press.,"H_2O	ΔH	1.500	Total F.H. Particulate,	mg	0.59
Static Pressure, "H_2O	P_{stat}	-2.50	Average $\sqrt{\Delta P}$., "H_2O	$\sqrt{\Delta P}$	0.063	B.H. Organics,	mg	N.A.
Stack Pressure, "Hg	P_s	29.72	Stack Area, Ft^2	A_s	0.087	B.H. Inorganics,	mg	N.A.
Stack Temp., °F	T_s	401.5	Nozzle Dia., Inches	D_n	0.752	Stack Gas O_2	O_2 %	11.5
Sample Time, mins	Θ	60.0	Meter Factor,	Y_d	1.0039	Stack Gas CO_2	CO_2 %	9.00
Std. Temp., °F	T_{std}	68	Sample Volume, Ft^3	V_m	37.985	Stack Gas N_2	N_2 %	79.5

A) Gas Volume $(V_m)_{std} = (T_{std}+460)*V_m*Y_d*(P_b+\Delta H/13.6)/((T_m+460)*29.92)$ = 36.296 DSCF

B) Volume H_2O collected $(V_w)_{std} = 8.9148E\text{-}5*(T_{std}+460)*V_w$ = 0.329 SCF

C) Total Sample Volume $(V_t)_{std} = (V_m)_{std} + (V_w)_{std}$ = 36.625 SCF

D) Moisture Content $(\%H_2O) = 100 * (V_w)_{std} / (V_t)_{std}$ = 0.9 %

E) Stack Gas Velocity $(Vs) = 85.49\ C_p\ \sqrt{(\Delta P)}\ (T_s \div 460/MW_s\ P_s)$ = 5.28 ft/sec

F) Stack Gas Molecular Wt.= $((CO_2\%*0.44+O_2\%*0.32+N_2\%*0.28)(1-H_2O\%/100))+18(H_2O\%/100)$ = 29.79 g/gm-mole

G) % Isokinetic (I) = $9142.88(V_t)(T_s+460)/((D_n^2)(\Theta)(P_s)(V_s)(T_{std}+460))$ = 102.70 %

H) ACFM = $(V_s)(A_s)60$ = 27.54 ACFM

I) Stack Gas Vol. Flow Rate, DSCFM = $(V_s)(A_s)((T_{std}+460)/(T_s+460))(P_s)(1-\%H_2O/100)*2.005$ = 16.61 DSCFM

J) F.H. Particulate Concentration (gr/DSCF) = mg/Vmstd * 0.01543 = 0.0003 gr/DSCF

K) F.H. Particulate Emission Rate = 0.00857 * gr/DSCF * DSCFM = 0.000036 Lbs/hr

EPA 17/114 PARTICULATE & RADIONUCLIDE EMISSION CALCULATIONS

FACILITY:	LLNL Bldg. 292	DATE:	8/26/98	METER BOX NO.:	ASI 8
UNIT:	GSS Filter Outlet	TIME:	0910-1010	PROBE NO.:	N.A.
CONDITION:	RTS #2 Waste Feed	TEST NO.:	1	NOZZLE NO.:	5E

Pitot Factor,	C_p	0.990	Meter Temp., °F	T_m	79.5	Total H_2O Condensed,	V_w	54.6
Barometric Press., "Hg	P_b	29.90	Meter Press.,"H_2O	ΔH	1.530	Total F.H. Particulate,	mg	0.42
Static Pressure, "H_2O	P_{stat}	-10.00	Average $\sqrt{\Delta P}$., "H_2O	$\sqrt{\Delta P}$	0.436	B.H. Organics,	mg	N.A.
Stack Pressure, "Hg	P_s	29.16	Stack Area, Ft^2	A_s	0.010	B.H. Inorganics,	mg	N.A.
Stack Temp., °F	T_s	308.4	Nozzle Dia., Inches	D_n	0.309	Stack Gas O_2,	O_2 %	9.9
Sample Time, mins	Θ	60	Meter Factor,	Y_d	0.9593	Stack Gas CO_2,	CO_2 %	8.50
Std. Temp., °F	T_{std}	68	Sample Volume, Ft^3	V_m	45.524	Stack Gas N_2,	N_2 %	81.6

A) Sample Volume $(V_m)_{std} = (T_{std}+460)*V_m*Y_d*(P_b+\Delta H/13.6)/((T_m+460)*29.92)$ = 42.872 DSCF

B) Volume H_2O collected $(V_w)_{std} = 8.9148E\text{-}5*(T_{std}+460)*V_w$ = 2.570 SCF

C) Total Sample Volume $(V_t)_{std} = (V_m)_{std} + (V_w)_{std}$ = 45.442 SCF

D) Moisture Content $(\%H_2O) = 100 * (V_w)_{std} / (V_t)_{std}$ = 5.7 %

E) Stack Gas Velocity (Vs) = $85.49\ C_p \sqrt{(\Delta P)}\ (T_s + 460/MW_s\ P_s)$ = 35.12 ft/sec

F) Stack Gas Molecular Wt.= $((CO_2\%*0.44+O_2\%*0.32+N_2\%*0.28)(1-H_2O\%/100))+18(H_2O\%/100)$ = 29.09 g/gm-mole

G) % Isokinetic (I) = $9142.88(V_t)(T_s+460)/((D_n^2)(\Theta)(P_s)(V_s)(T_{std}+460))$ = 103.05 %

H) ACFM = $(V_s)(A_s)60$ = 21.07 ACFM

I) Stack Gas Vol. Flow Rate, DSCFM = $(V_s)(A_s)((T_{std}+460)/(T_s+460))(P_s)(1-\%H_2O/100)*2.005$ = 13.31 DSCFM

J) F.H. Particulate Concentration (gr/DSCF) = mg/Vmstd * 0.01543 = 0.0002 gr/DSCF

K) F.H. Particulate Emission Rate = 0.00857 * gr/DSCF * DSCFM = 0.000 lbs/hr

EPA 17/114 PARTICULATE & RADIONUCLIDE EMISSION CALCULATIONS

FACILITY:	LLNL Bldg. 292	DATE:	8/26/98	METER BOX NO.:	ASI 8
UNIT:	GSS Filter Outlet	TIME:	1100-1200	PROBE NO.:	N.A.
CONDITION:	RTS #2 Waste Feed	TEST NO.:	2	NOZZLE NO.:	5E

Pitot Factor,	C_p	0.99	Meter Temp., °F	T_m	80.6	Total H_2O Condensed,	V_w	35.0
Barometric Press., "Hg	P_b	29.90	Meter Press.,"H_2O	ΔH	1.820	Total F.H. Particulate,	mg	0.52
Static Pressure, "H_2O	P_{stat}	-10.00	Average $\sqrt{\Delta P}$., "H_2O	$\sqrt{\Delta P}$	0.483	B.H. Organics,	mg	N.A.
Stack Pressure, "Hg	P_s	29.16	Stack Area, Ft^2	A_s	0.010	B.H. Inorganics,	mg	N.A.
Stack Temp., °F	T_s	327.4	Nozzle Dia., Inches	D_n	0.309	Stack Gas O_2	O_2 %	10.5
Sample Time, mins	Θ	60.0	Meter Factor,	Y_d	0.9593	Stack Gas CO_2	CO_2 %	7.00
Std. Temp., °F	T_{std}	68	Sample Volume, Ft^3	V_m	49.443	Stack Gas N_2	N_2 %	82.5

A) Sample Volume $(V_m)_{std} = (T_{std}+460)*V_m*Y_d*(P_b+\Delta H/13.6)/((T_m+460)*29.92) =$ 46.501 DSCF

B) Volume H_2O collected $(V_w)_{std} = 8.9148E\text{-}5*(T_{std}+460)*V_w =$ 1.647 SCF

C) Total Sample Volume $(V_t)_{std} = (V_m)_{std} + (V_w)_{std} =$ 48.149 SCF

D) Moisture Content $(\%H_2O) = 100 * (V_w)_{std} / (V_t)_{std} =$ 3.4 %

E) Stack Gas Velocity $(Vs) = 85.49\ C_p\ \sqrt{(\Delta P)}\ (T_s + 460/MW_s\ P_s) =$ 39.34 ft/sec

F) Stack Gas Molecular Wt.$= ((CO_2\%*0.44+O_2\%*0.32+N_2\%*0.28)(1-H_2O\%/100))+18(H_2O\%/100) =$ 29.15 g/gm-mole

G) % Isokinetic $(I) = 9142.88(V_t)(T_s+460)/((D_n^2)(\Theta)(P_s)(V_s)(T_{std}+460)) =$ 99.87 %

H) $ACFM = (V_s)(A_s)60 =$ 23.61 ACFM

I) Stack Gas Vol. Flow Rate, $DSCFM = (V_s)(A_s)((T_{std}+460)/(T_s+460))(P_s)(1-\%H_2O/100)*2.005 =$ 14.90 DSCFM

J) F.H. Particulate Concentration (gr/DSCF) = mg/Vmstd * 0.01543 = 0.0002 gr/DSCF

K) F.H. Particulate Emission Rate = 0.00857 * gr/DSCF * DSCFM = 0.000 Lbs/hr

EPA 17/114 PARTICULATE & RADIONUCLIDE EMISSION CALCULATIONS

FACILITY:	LLNL Bldg. 292	DATE:	8/26/98	METER BOX NO.:	ASI 8
UNIT:	GSS Filter Outlet	TIME:	1245-1345	PROBE NO.:	N.A.
CONDITION:	RTS #2 Waste Feed	TEST NO.:	3	NOZZLE NO.:	5E

Pitot Factor,	C_p	0.990	Meter Temp., °F	T_m	81.6	Total H_2O Condensed,	V_w	40.3
Barometric Press., "Hg	P_b	29.90	Meter Press.,"H_2O	ΔH	1.490	Total F.H. Particulate,	mg	1.50
Static Pressure, "H_2O	P_{stat}	-10.00	Average $\sqrt{\Delta P}$., "H_2O	$\sqrt{\Delta P}$	0.443	B.H. Organics,	mg	N.A.
Stack Pressure, "Hg	P_s	29.16	Stack Area, Ft^2	A_s	0.010	B.H. Inorganics,	mg	N.A.
Stack Temp., °F	T_s	335.3	Nozzle Dia., Inches	D_n	0.309	Stack Gas O_2	O_2 %	10.1
Sample Time, mins	Θ	60.0	Meter Factor,	Y_d	0.9593	Stack Gas CO_2	CO_2 %	7.30
Std. Temp., °F	T_{std}	68	Sample Volume, Ft^3	V_m	45.484	Stack Gas N_2	N_2 %	82.6

A) Gas Volume $(V_m)_{std} = (T_{std}+460)*V_m*Y_d*(P_b+\Delta H/13.6)/((T_m+460)*29.92)$ = 42.664 DSCF

B) Volume H_2O collected $(V_w)_{std} = 8.9148E\text{-}5*(T_{std}+460)*V_w$ = 1.897 SCF

C) Total Sample Volume $(V_t)_{std} = (V_m)_{std} + (V_w)_{std}$ = 44.561 SCF

D) Moisture Content $(\%H_2O) = 100 * (V_w)_{std} / (V_t)_{std}$ = 4.3 %

E) Stack Gas Velocity $(Vs) = 85.49\ C_p\ \sqrt{(\Delta P)}\ (T_s + 460/MW_s\ P_s)$ = 36.31 ft/sec

F) Stack Gas Molecular Wt.= $((CO_2\%*0.44+O_2\%*0.32+N_2\%*0.28)(1-H_2O\%/100))+18(H_2O\%/100)$ = 29.08 g/gm-mole

G) % Isokinetic $(I) = 9142.88(V_t)(T_s+460)/((D_n^2)(\Theta)(P_s)(V_s)(T_{std}+460))$ = 101.16 %

H) $ACFM = (V_s)(A_s)60$ = 21.78 ACFM

I) Stack Gas Vol. Flow Rate, $DSCFM = (V_s)(A_s)((T_{std}+460)/(T_s+460))(P_s)(1-\%H_2O/100)*2.005$ = 13.50 DSCFM

J) F.H. Particulate Concentration (gr/DSCF) = mg/Vmstd * 0.01543 = 0.0005 gr/DSCF

K) F.H. Particulate Emission Rate = 0.00857 * gr/DSCF * DSCFM = 0.000 Lbs/hr

EPA 17/114 PARTICULATE & RADIONUCLIDE EMISSION CALCULATIONS

FACILITY:	LLNL Bldg. 292	DATE:	8/26/98	METER BOX NO.:	LSI 1
UNIT:	Catalyst Outlet	TIME:	1040-1140	PROBE NO.:	N.A.
CONDITION:	Normal	TEST NO.:	1	NOZZLE NO.:	41

Pitot Factor,	C_p	0.990	Meter Temp., °F	T_m	94.2	Total H_2O Condensed,	V_w	7.0
Barometric Press., "Hg	P_b	29.90	Meter Press.,"H_2O	ΔH	1.300	Total F.H. Particulate,	mg	0.16
Static Pressure, "H_2O	P_{stat}	-2.50	Average $\sqrt{\Delta P}$., "H_2O	$\sqrt{\Delta P}$	0.0632	B.H. Organics,	mg	N.A.
Stack Pressure, "Hg	P_s	29.72	Stack Area, Ft^2	A_s	0.087	B.H. Inorganics,	mg	N.A.
Stack Temp., °F	T_s	390.8	Nozzle Dia., Inches	D_n	0.752	Stack Gas O_2	O_2 %	10.5
Sample Time, mins	Θ	60.0	Meter Factor,	Y_d	1.0039	Stack Gas CO_2	CO_2 %	7.20
Std. Temp., °F	T_{std}	68	Sample Volume, Ft^3	V_m	34.803	Stack Gas N_2	N_2 %	82.3

A) Gas Volume $(V_m)_{std} = (T_{std}+460)*V_m*Y_d*(P_b+\Delta H/13.6)/((T_m+460)*29.92) =$ 33.371 DSCF

B) Volume H_2O collected $(V_w)_{std} = 8.9148E\text{-}5*(T_{std}+460)*V_w =$ 0.329 SCF

C) Total Sample Volume $(V_t)_{std} = (V_m)_{std} + (V_w)_{std} =$ 33.701 SCF

D) Moisture Content $(\%H_2O) = 100 * (V_w)_{std} / (V_t)_{std} =$ 1.0 %

E) Stack Gas Velocity (Vs) = $85.49\ C_p\ \sqrt{(\Delta P)}\ (T_s + 460/MW_s\ P_s) =$ 5.27 ft/sec

F) Stack Gas Molecular Wt.= $((CO_2\%*0.44+O_2\%*0.32+N_2\%*0.28)(1-H_2O\%/100))+18(H_2O\%/100) =$ 29.46 g/gm-mole

G) % Isokinetic (I) = $9142.88(V_t)(T_s+460)/((D_n^2)(\Theta)(P_s)(V_s)(T_{std}+460)) =$ 93.38 %

H) ACFM = $(V_s)(A_s)60 =$ 27.53 ACFM

I) Stack Gas Vol. Flow Rate, DSCFM = $(V_s)(A_s)((T_{std}+460)/(T_s+460))(P_s)(1-\%H_2O/100)*2.005 =$ 16.80 DSCFM

J) F.H. Particulate Concentration (gr/DSCF) = mg/Vmstd * 0.01543 = 0.0001 gr/DSCF

K) F.H. Particulate Emission Rate = 0.00857 * gr/DSCF * DSCFM = 0.000 Lbs/hr

HCl Sample Train Meter Volume

Facility: LLNL Bldg. 292
Unit: GSS Filter Outlet
Condition: RTS #1 Waste Feed
Date: 8/19/98
Time:

	Run 1	Run 2	Run 3	
1a. Uncorrected Meter Volume (Vm)	0.1185	0.1183	0.1181	m^3
1b. Uncorrected Meter Volume (Vm)	4.185	4.178	4.171	ft^3
2. Meter Factor (Yd)	0.9818	0.9818	0.9818	
3. Barometric Pressure (Pb)	29.90	29.90	29.90	"Hg
4. Meter Pressure (ΔH)	0.00	0.00	0.00	"H_2O
5. Meter Temperature (Tm)	78.8	83.6	84.8	°F
6. Std. Temperature (Tstd)	68	68	68	°F
7. Impinger H_2O Gain (Vw imp)	0.0	0.0	0.0	g
8. Silica Gel Wt. Gain (Vw sg)	0.0	0.0	0.0	g
9. Total H_2O Gain (Vw)	0.0	0.0	0.0	g
10. Moisture Vapor (Vw std)	0.0	0.0	0.0	%
Std. Meter Volume (Vm std)	**4.024**	**3.981**	**3.966**	**DSCF**
Std. Meter Volume (Vm std)	**0.1139**	**0.1127**	**0.1123**	**DSCM**

WHERE:

ft^3 = Cubic Feet
H_20 = Water
Hg = Mercury
°F = Fahrenheit
ml = milliliters
g = grams
% = Percent

DSCF = Dry Standard Cubic Foot
DSCM = Dry Standard Cubic Meter

CALCULATIONS:

Vw std = 0.00267 * Vw * (Tstd + 460) / 29.92
Vm std = Vm * Yd * (Tstd + 460) * (Pb +(ΔH/13.6)) / (Tm + 460) / 29.92
Stack Moisture H_2O % = 100 * Vw std / (Vw std + Vm std)

HCl Sample Train Meter Volume

Facility: LLNL Bldg. 292
Unit: GSS Filter Outlet
Condition: RTS #2 Waste Feed
Date: 8/26/98
Time:

	Run 1	Run 2	Run 3	
1a. Uncorrected Meter Volume (Vm)	0.1247	0.1450	0.1208	m^3
1b. Uncorrected Meter Volume (Vm)	4.404	5.121	4.266	ft^3
2. Meter Factor (Yd)	0.9818	0.9818	0.9818	
3. Barometric Pressure (Pb)	29.90	29.90	29.90	"Hg
4. Meter Pressure (ΔH)	0.00	0.00	0.00	"H_2O
5. Meter Temperature (Tm)	80.0	81.8	83.6	°F
6. Std. Temperature (Tstd)	68	68	68	°F
7. Impinger H_2O Gain (Vw imp)	0.0	0.0	0.0	g
8. Silica Gel Wt. Gain (Vw sg)	0.0	0.0	0.0	g
9. Total H_2O Gain (Vw)	0.0	0.0	0.0	g
10. Moisture Vapor (Vw std)	0.0	0.0	0.0	%
Std. Meter Volume (Vm std)	**4.225**	**4.896**	**4.066**	**DSCF**
Std. Meter Volume (Vm std)	**0.1196**	**0.1386**	**0.1151**	**DSCM**

WHERE:

ft^3 = Cubic Feet
H_20 = Water
Hg = Mercury
°F = Fahrenheit
ml = milliliters
g = grams
% = Percent

DSCF = Dry Standard Cubic Foot
DSCM = Dry Standard Cubic Meter

CALCULATIONS:

Vw std = 0.00267 * Vw * (Tstd + 460) / 29.92
Vm std = Vm * Yd * (Tstd + 460) * (Pb +(ΔH/13.6)) / (Tm + 460) / 29.92
Stack Moisture H_2O % = 100 * Vw std / (Vw std + Vm std)

APPENDIX B
LAB REPORTS

PHILIP SERVICES

ORGANIC DATA PACKAGE
FOR
BEST ENVIRONMENTAL INC.
Project: Livermore

Philip Analytical Services Corporation
5555 North Service Road
Burlington, Ontario L7L 5H7

Submission #8I0098

Prepared by: Ancy Sebastian - CSR Initial : JO
Approved by: Dr. Ron McLeod - Principal Scientist Initial : KVN

000070

357

PROJECT NARRATIVE

PHILIP Analytical Services (Burlington ON)
Philip Project: AN980845
Philip Submission #:8I0098

Client: Best Environmental Inc.
Client Project: Livermore

I. SAMPLE RECEIPT/ANALYSIS

a) Sample Listing

Philip ID	Client Sample ID	Date Sampled	Date Received	Date Prepped	Run Date
Polychlorinated Biphenyls via CARB 428 Method					
043156 98	Method Blank	98/08/26	98/08/28	98/09/27	98/10/05
043157 98	R4M23-TB	98/08/26	98/08/28	98/09/27	98/10/05
043158 98	R1M23 Baghouse Inlet	98/08/26	98/08/28	98/09/27	98/10/05
043159 98	R2M23 Baghouse Inlet	98/08/26	98/08/28	98/09/27	98/10/05
043160 98	R3M23 Baghouse Inlet	98/08/26	98/08/28	98/09/27	98/10/05
043161 98	R1M23 Cot Outlet	98/08/26	98/08/28	98/09/27	98/10/05
Semi-Volatiles via SW846 Method 8270					
043156 98	Method Blank	98/08/26	98/08/28	98/09/27	98/10/05
043157 98	R4M23-TB	98/08/26	98/08/28	98/09/27	98/10/05
043158 98	R1M23 Baghouse Inlet	98/08/26	98/08/28	98/09/27	98/10/05
043159 98	R2M23 Baghouse Inlet	98/08/26	98/08/28	98/09/27	98/10/05
043160 98	R3M23 Baghouse Inlet	98/08/26	98/08/28	98/09/27	98/10/05
043161 98	R1M23 Cot Outlet	98/08/26	98/08/28	98/09/27	98/10/05
043163 98	R1M429 BaghouseInlet	98/08/18	98/08/28	98/09/27	98/10/05
043164 98	R2M429 BaghouseInlet	98/08/18	98/08/28	98/09/27	98/10/05
043165 98	R3M429 BaghouseInlet	98/08/19	98/08/28	98/09/27	98/10/05
043166 98	R1M429 Cat Outlet	98/08/18	98/08/28	98/09/27	98/10/05
VOST via SW846 Method 5041A/8260B					
043187 98	LLNL Field Blank	98/08/18	98/08/28	98/09/04	98/09/04
043188 98	LLNL Trip Blank	98/08/18	98/08/28	98/09/04	98/09/04
043189 98	RTS#1/R1/0030 15a/b	98/08/18	98/08/28	98/09/04	98/09/04
043190 98	RTS#1/R1/0030 2a/b	98/08/18	98/08/28	98/09/04	98/09/04
043191 98	RTS#1/R1/0030 3a/b	98/08/18	98/08/28	98/09/04	98/09/04
043192 98	RTS#1/R2/0030 4a/b	98/08/18	98/08/28	98/09/04	98/09/04
043193 98	RTS#1/R2/0030 5a/b	98/08/18	98/08/28	98/09/04	98/09/04
043194 98	RTS#1/R2/0030 6a/b	98/08/18	98/08/28	98/09/04	98/09/04
043195 98	RTS#1/R3/0030 8a/b	98/08/18	98/08/28	98/09/04	98/09/04
043196 98	RTS#1/R3/0030 9a/b	98/08/18	98/08/28	98/09/04	98/09/04
043197 98	RTS#1/R3/0030 10a/b	98/08/18	98/08/28	98/09/04	98/09/04
043198 98	RTS#1/R1CAT 11a/b	98/08/18	98/08/28	98/09/09	98/09/09
043199 98	RTS#1/R1CAT 13a/b	98/08/18	98/08/28	98/09/09	98/09/09

043200 98	RTS#1/R1CAT 14a/b	98/08/18	98/08/28	98/09/09	98/09/09
043201 98	LLNL Field Blank	98/08/18	98/08/28	98/09/09	98/09/09
043202 98	RTS#2/R1/0030 23a/b	98/08/26	98/08/28	98/09/08	98/09/08
043203 98	RTS#2/R1/0030 22a/b	98/08/26	98/08/28	98/09/08	98/09/08
043204 98	RTS#2/R1/0030 21a/b	98/08/26	98/08/28	98/09/08	98/09/08
043205 98	RTS#2/R2/0030 20a/b	98/08/26	98/08/28	98/09/08	98/09/08
043206 98	RTS#2/R2/0030 19a/b	98/08/26	98/08/28	98/09/08	98/09/08
043207 98	RTS#2/R2/0030 18a/b	98/08/26	98/08/28	98/09/08	98/09/08
043208 98	RTS#2/R3/0030 17a/b	98/08/26	98/08/28	98/09/08	98/09/08
043209 98	RTS#2/R3/0030 16a/b	98/08/26	98/08/28	98/09/09	98/09/09
043210 98	RTS#2/R3/0030 1a/b	98/08/26	98/08/28	98/09/09	98/09/09
043211 98	RTS#2/R1CAT 2a/b	98/08/26	98/08/28	98/09/09	98/09/09
043212 98	RTS#2/R1CAT 3a/b	98/08/26	98/08/28	98/09/09	98/09/09
043213 98	RTS#2/R1CAT 4a/b	98/08/26	98/08/28	98/09/09	98/09/09

PCDD/F(DB5) via EPA Method 23-Primary Column Analysis

043156 98	Method Blank	98/08/26	98/08/28	98/09/27	98/10/05
043157 98	R4M23-TB	98/08/26	98/08/28	98/09/27	98/10/02
043158 98	R1M23 Baghouse Inlet	98/08/26	98/08/28	98/09/27	98/10/04
043159 98	R2M23 Baghouse Inlet	98/08/26	98/08/28	98/09/27	98/10/04
043160 98	R3M23 Baghouse Inlet	98/08/26	98/08/28	98/09/27	98/10/04
043161 98	R1M23 Cot Outlet	98/08/26	98/08/28	98/09/27	98/10/07
043163 98	R1M429 BaghouseInlet	98/08/18	98/08/28	98/09/27	98/10/04
043164 98	R2M429 BaghouseInlet	98/08/18	98/08/28	98/09/27	98/10/04
043165 98	R3M429 BaghouseInlet	98/08/19	98/08/28	98/09/27	98/10/04
043166 98	R1M429 Cat Outlet	98/08/18	98/08/28	98/09/27	98/10/04

PCDD/F(DB225) via EPA Method 23-Confirmational Analysis

043156 98	Method Blank	98/08/26	98/08/28	98/09/27	98/10/20
043157 98	R4M23-TB	98/08/26	98/08/28	98/09/27	98/10/20
043158 98	R1M23 Baghouse Inlet	98/08/26	98/08/28	98/09/27	98/10/20
043159 98	R2M23 Baghouse Inlet	98/08/26	98/08/28	98/09/27	98/10/20
043160 98	R3M23 Baghouse Inlet	98/08/26	98/08/28	98/09/27	98/10/20
043161 98	R1M23 Cot Outlet	98/08/26	98/08/28	98/09/27	98/10/20
043163 98	R1M429 BaghouseInlet	98/08/18	98/08/28	98/09/27	98/10/20
043164 98	R2M429 BaghouseInlet	98/08/18	98/08/28	98/09/27	98/10/20
043165 98	R3M429 BaghouseInlet	98/08/19	98/08/28	98/09/27	98/10/20
043166 98	R1M429 Cat Outlet	98/08/18	98/08/28	98/09/27	98/10/20

Run Date is defined as the date of injection of the last calibration standard (12 hour or less) prior to the samples analyzed within that run sequence. Therefore the time of calibration injection that defines the run date is always within 12 hours of the time of sample injection.

b) Shipping Problems: none encountered

VOST Samples were shipped in the same container as the SV solvents. Therefore significant background of recovery solvents were observed in the VOST samples during analysis.

c) Documentation Problems: none encountered

PHILIP SERVICES

M23

Certificate of Analysis

CLIENT INFORMATION		LABORATORY INFORMATION	
Attention:	Dan Cartner	**Contact:**	Ron McLeod
Client Name:	Best Environmental Inc.	**Project:**	AN980845
Project:	Livermore	**Date Received:**	98/08/28
Project Desc:	Stack Emissions	**Date Reported:**	98/10/09
Address:	15890 Foothill Blvd San Leandro,CA CA 94578	**Submission No.:**	8I0098
		Sample No.:	043156
Fax Number:	510 278 4018		
Phone Number:	510 278 4011		

NOTES: *"-' = not analysed '<' = less than Method Detection Limit (MDL) 'NA' = no data available*
LOQ can by determined for all analytes by multiplying the appropriate MDL X 3.33
Solids data is based on dry weight except for biota analyses.
Organic analyses are not corrected for extraction recovery standards except for isotope dilution methods, (i.e. CARB 429 PAH, all PCDD/F and DBD/DBF analyses)

Methods used by PASC are based upon those found in 'Standard Methods for the Examination of Water and Wastewater', Nineteenth Edition. Other methods are based on the principles of MISA or EPA methodologies. New York State: ELAP Identification Number 10756.

All work recorded herein has been done in accordance with normal professional standards using accepted testing methodologies, quality assurance and quality control procedures except where otherwise agreed to by the client and testing company in writing. Any and all use of these test results shall be limited to the actual cost of the pertinent analysis done. There is no other warranty expressed or implied. Your samples will be retained at PASC for a period of three weeks from receipt of data or as per contract.

COMMENTS: Revision 98/10/23: Confirmation Data

Certified by: _____

PHILIP ANALYTICAL SERVICES CORPORATION
5555 North Service Road, Burlington, Ontario, Canada L7L 5H7 Tel: (905) 332-8788 Fax: (905) 332-9169

Client ID:		Method Blank	Blank Spike #1	Blank Spike #1	Blank Spike #2	Blank Spike #2
Lab No.:		043156 98	043156 98	043156 98	043156 98	043156 98
Date Sampled:		98/08/26	98/08/26	98/08/26	98/08/26	98/08/26
Component	**Units**			% Recoveries		% Recoveries
Total Cl4-Dibenzofurans	pg	19	5300	107	4900	99
Total Cl5-Dibenzofurans	"	<24	11000	110	11000	113
Total Cl6-Dibenzofurans	"	<22	23000	112	23000	118
Total Cl7-Dibenzofurans	"	<6.3	11000	110	11000	105
Cl8-Dibenzofuran	"	<7.1	11000	110	12000	117
Total Cl4-Dibenzo-p-dioxins	"	<19	6400	127	6500	130
Total Cl5-Dibenzo-p-dioxins	"	62	6200	124	6200	124
Total Cl6-Dibenzo-p-dioxins	"	<8.9	19000	125	19000	122
Total Cl7-Dibenzo-p-dioxins	"	<9.8	6000	120	6300	125
Cl8-Dibenzo-p-dioxin	"	9.6	11000	110	12000	116
Internal Recoveries	%					
2,3,7,8-T4CDF-13C-12		68	72	72	70	70
2,3,7,8-T4CDD-13C-12		70	71	71	69	69
1,2,3,7,8-P5CDF-13C-12		81	88	88	74	74
1,2,3,7,8-P5CDD-13C-12		89	95	95	79	79
1,2,3,6,7,8-H6CDF-13C-12		87	92	92	89	89
1,2,3,6,7,8-H6CDD-13C-12		95	96	96	94	94
1,2,3,4,6,7,8-H7CDF-13C-12		88	89	89	82	82
1,2,3,4,6,7,8-H7CDD-13C-12		93	93	93	87	87
OCDD-13C-12		87	89	89	78	78
Surrogate Recoveries	%					
2,3,7,8-T4CDD-37Cl4		NS	NS	NS	NS	NS
2,3,4,7,8-P5CDF-13C-12		NS	NS	NS	NS	NS
1,2,3,4,7,8-H6CDF-13C-12		NS	NS	NS	NS	NS
1,2,3,4,7,8-H6CDD-13C-12		NS	NS	NS	NS	NS
1,2,3,4,7,8,9-H7CDF-13C-12		NS	NS	NS	NS	NS
Alternate	%					
1,2,3,7,8,9-H6CDF-13C-12		105	102	102	106	106
2,3,7,8-Cl4-Dibenzofuran (DB5)	pg	19	5300	107	4900	98
2,3,7,8-Cl4-Dibenzo-p-dioxin	"	<19	6400	127	6500	130
1,2,3,7,8-Cl5-Dibenzofuran	"	<6.9	5500	109	5300	106
2,3,4,7,8-Cl5-Dibenzofuran	"	<25	5500	111	5900	119
1,2,3,7,8-Cl5-Dibenzo-p-dioxin	"	<6.5	6200	124	6200	124
1,2,3,4,7,8-Cl6-Dibenzofuran	"	<8.1	5100	102	5600	112
1,2,3,6,7,8-Cl6-Dibenzofuran	"	<7.2	6200	125	5900	119
2,3,4,6,7,8-Cl6-Dibenzofuran	"	<9.2	5700	115	6500	129
1,2,3,7,8,9-Cl6-Dibenzofuran	"	<9.6	5300	107	5500	110
1,2,3,4,7,8-Cl6-Dibenzo-p-dioxin	"	<9.2	6000	120	5500	110
1,2,3,6,7,8-Cl6-Dibenzo-p-dioxin	"	<8.6	6400	129	6400	129
1,2,3,7,8,9-Cl6-Dibenzo-p-dioxin	"	<8.9	6200	125	6400	128
1,2,3,4,6,7,8-Cl7-Dibenzofuran	"	<5.9	6000	120	5400	108
1,2,3,4,7,8,9-Cl7-Dibenzofuran	"	<6.6	5300	106	5100	102
1,2,3,4,6,7,8-Cl7-Dibenzo-p-dioxin	"	<9.8	6000	120	6300	125
1,2,3,4,6,7,8,9-Cl8-Dibenzofuran	"	<7.1	11000	110	12000	117
1,2,3,4,6,7,8,9-Cl8-Dibenzo-p-dioxin	"	9.6	11000	110	12000	116

		Method	Blank	Blank	Blank	Blank
Client ID:		Blank	Spike #1	Spike #1	Spike #2	Spike #2
Lab No.:		043156 98	043156 98	043156 98	043156 98	043156 98
Date Sampled:		98/08/26	98/08/26	98/08/26	98/08/26	98/08/26
Component	**Units**			% Recoveries		% Recoveries
2,3,7,8-TCDF (DB225)	pg	19	-	-	-	-
Internal Recoveries	%					
2,3,7,8-TCDF-13C12		56	-	-	-	-

Client ID:		R4M23-TB	R1M23 Baghouse Inlet	R2M23 Baghouse Inlet	R3M23 Baghouse Inlet
Lab No.:		043157 98	043158 98	043159 98	043160 98
Date Sampled:		98/08/26	98/08/26	98/08/26	98/08/26
Component	**Units**				
Total Cl4-Dibenzofurans	pg	31	390	220	510
Total Cl5-Dibenzofurans	"	34	66	120	360
Total Cl6-Dibenzofurans	"	<14	18	31	79
Total Cl7-Dibenzofurans	"	<14	6.5	14	23
Cl8-Dibenzofuran	"	<36	13	8.9	9.0
Total Cl4-Dibenzo-p-dioxins	"	31	100	94	58
Total Cl5-Dibenzo-p-dioxins	"	40	24	34	15
Total Cl6-Dibenzo-p-dioxins	"	<44	9.1	20	10
Total Cl7-Dibenzo-p-dioxins	"	<23	12	26	13
Cl8-Dibenzo-p-dioxin	"	<52	290	200	230
Internal Recoveries	%				
2,3,7,8-T4CDF-13C-12		85	86	84	87
2,3,7,8-T4CDD-13C-12		74	82	79	77
1,2,3,7,8-P5CDF-13C-12		80	76	82	76
1,2,3,7,8-P5CDD-13C-12		85	76	84	74
1,2,3,6,7,8-H6CDF-13C-12		129	114	125	130
1,2,3,6,7,8-H6CDD-13C-12		129	110	104	104
1,2,3,4,6,7,8-H7CDF-13C-12		98	88	98	95
1,2,3,4,6,7,8-H7CDD-13C-12		86	79	90	86
OCDD-13C-12		87	76	87	83
Surrogate Recoveries	%				
2,3,7,8-T4CDD-37Cl4		95	102	100	98
2,3,4,7,8-P5CDF-13C-12		108	107	106	104
1,2,3,4,7,8-H6CDF-13C-12		77	85	82	82
1,2,3,4,7,8-H6CDD-13C-12		73	85	104	104
1,2,3,4,7,8,9-H7CDF-13C-12		88	90	91	88
Alternate	%				
1,2,3,7,8,9-H6CDF-13C-12		99	100	101	106
2,3,7,8-Cl4-Dibenzofuran (DB5)	pg	31	60	65	81
2,3,7,8-Cl4-Dibenzo-p-dioxin	"	31	44	54	45
1,2,3,7,8-Cl5-Dibenzofuran	"	<22	12	19	52
2,3,4,7,8-Cl5-Dibenzofuran	"	35	36	51	52
1,2,3,7,8-Cl5-Dibenzo-p-dioxin	"	<33	15	23	15
1,2,3,4,7,8-Cl6-Dibenzofuran	"	<13	7.5	8.1	14
1,2,3,6,7,8-Cl6-Dibenzofuran	"	<12	4.6	4.5	12
2,3,4,6,7,8-Cl6-Dibenzofuran	"	<15	5.8	6.4	12
1,2,3,7,8,9-Cl6-Dibenzofuran	"	<15	<5.1	1.4	6.7
1,2,3,4,7,8-Cl6-Dibenzo-p-dioxin	"	<45	<4.2	4.5	<4.6
1,2,3,6,7,8-Cl6-Dibenzo-p-dioxin	"	<42	4.3	5.1	5.7
1,2,3,7,8,9-Cl6-Dibenzo-p-dioxin	"	<44	4.7	5.1	4.5
1,2,3,4,6,7,8-Cl7-Dibenzofuran	"	<14	6.2	6.1	9.9
1,2,3,4,7,8,9-Cl7-Dibenzofuran	"	<15	<5.0	<5.1	6.2
1,2,3,4,6,7,8-Cl7-Dibenzo-p-dioxin	"	<23	<14	15	13
1,2,3,4,6,7,8,9-Cl8-Dibenzofuran	"	<36	13	8.9	9.0
1,2,3,4,6,7,8,9-Cl8-Dibenzo-p-dioxin	"	<52	290	200	230

	Client ID:	R4M23-TB	R1M23 Baghouse Inlet	R2M23 Baghouse Inlet	R3M23 Baghouse Inlet
	Lab No.:	043157 98	043158 98	043159 98	043160 98
	Date Sampled:	98/08/26	98/08/26	98/08/26	98/08/26
Component	**Units**				
2,3,7,8-TCDF (DB225)	pg	20	<20	30	33
Internal Recoveries	%				
2.3,7,8-TCDF-13C12		77	77	74	83

		R1M23 Cot Outlet	R1M429 BaghouseInlet	R2M429 BaghouseInlet	R3M429 BaghouseInlet	R1M429 Cat Outlet
Client ID:						
Lab No.:		043161 98	043163 98	043164 98	043165 98	043166 98
Date Sampled:		98/08/26	98/08/18	98/08/18	98/08/19	98/08/18
Component	**Units**					
Total Cl4-Dibenzofurans	pg	14	34	35	31	49
Total Cl5-Dibenzofurans	"	22	58	68	56	94
Total Cl6-Dibenzofurans	"	5.7	16	23	20	22
Total Cl7-Dibenzofurans	"	<4.2	<4.2	<6.0	9.2	<11
Cl8-Dibenzofuran	"	<7.1	7.6	9.0	22	<8.9
Total Cl4-Dibenzo-p-dioxins	"	30	39	50	34	47
Total Cl5-Dibenzo-p-dioxins	"	7.5	14	21	13	27
Total Cl6-Dibenzo-p-dioxins	"	<4.0	<4.1	11	<7.5	<8.1
Total Cl7-Dibenzo-p-dioxins	"	<4.4	8.2	18	30	10
Cl8-Dibenzo-p-dioxin	"	9.4	22	250	500	97
Internal Recoveries	%					
2,3,7,8-T4CDF-13C-12		93	82	84	80	68
2,3,7,8-T4CDD-13C-12		80	74	76	71	60
1,2,3,7,8-P5CDF-13C-12		84	82	81	80	70
1,2,3,7,8-P5CDD-13C-12		87	84	82	81	72
1,2,3,6,7,8-H6CDF-13C-12		109	113	107	100	101
1,2,3,6,7,8-H6CDD-13C-12		98	105	102	104	99
1,2,3,4,6,7,8-H7CDF-13C-12		99	98	95	96	88
1,2,3,4,6,7,8-H7CDD-13C-12		93	90	86	89	86
OCDD-13C-12		86	88	85	88	82
Surrogate Recoveries	%					
2 3,7,8-T4CDD-37Cl4		98	97	99	96	97
2,3,4,7,8-P5CDF-13C-12		105	105	105	106	106
1,2,3,4,7,8-H6CDF-13C-12		95	95	93	98	93
1,2,3,4,7,8-H6CDD-13C-12		107	102	102	101	95
1,2,3,4,7,8,9-H7CDF-13C-12		93	93	94	98	93
Alternate	%					
1,2,3,7,8,9-H6CDF-13C-12		102	103	100	99	97
2,3,7,8-Cl4-Dibenzofuran (DB5)	pg	14	34	35	31	49
2,3,7,8-Cl4-Dibenzo-p-dioxin	"	30	39	50	34	47
1,2,3,7,8-Cl5-Dibenzofuran	"	5.0	12	18	13	22
2,3,4,7,8-Cl5-Dibenzofuran	"	18	41	51	37	58
1,2,3,7,8-Cl5-Dibenzo-p-dioxin	"	7.5	14	21	13	27
1,2,3,4,7,8-Cl6-Dibenzofuran	"	5.5	6.3	8.7	8.8	8.3
1,2,3,6,7,8-Cl6-Dibenzofuran	"	<4.0	3.5	5.9	4.7	5.9
2,3,4,6,7,8-Cl6-Dibenzofuran	"	<5.0	6.3	7.4	6.1	7.5
1,2,3,7,8,9-Cl6-Dibenzofuran	"	<5.2	<4.5	<4.6	<4.9	<4.2
1,2,3,4,7,8-Cl6-Dibenzo-p-dioxin	"	<4.2	<4.2	6.3	<7.7	<8.4
1,2,3,6,7,8-Cl6-Dibenzo-p-dioxin	"	<3.9	<4.0	5.0	<7.2	<7.8
1,2,3,7,8,9-Cl6-Dibenzo-p-dioxin	"	<4.0	<4.1	<3.6	<7.5	<8.1
1,2,3,4,6,7,8-Cl7-Dibenzofuran	"	<3.9	<4.0	<5.6	8.7	<10
1,2,3,4,7,8,9-Cl7-Dibenzofuran	"	<4.4	<4.4	<6.3	<5.4	<12
1,2,3,4,6,7,8-Cl7-Dibenzo-p-dioxin	"	<4.4	8.2	11	17	10
1,2,3,4,6,7,8,9-Cl8-Dibenzofuran	"	<7.1	7.6	9.0	22	<8.9
1,2,3,4,6,7,8,9-Cl8-Dibenzo-p-dioxin	"	9.4	22	250	500	97

		R1M23 Cot Outlet	R1M429 BaghouseInlet	R2M429 BaghouseInlet	R3M429 BaghouseInlet	R1M429 Cat Outlet
Client ID:						
Lab No.:		043161 98	043163 98	043164 98	043165 98	043166 98
Date Sampled:		98/08/26	98/08/18	98/08/18	98/08/19	98/08/18
Component	**Units**					
2,3,7,8-TCDF (DB225)	pg	13	17	29	21	36
Internal Recoveries	%					
2,3,7,8-TCDF-13C12		83	84	84	83	69

Batch Code:	**0927FB01**	**0927FB01**	**0927FB01**	**0927FB01**
PCDD/F (DB5)	043156 98	043157 98	043158 98	043161 98
			043159 98	
			043160 98	
			043163 98	
			043164 98	
			043165 98	
			043166 98	
Run Date	98/10/05	98/10/02	98/10/04	98/10/07
Date of Sample Prep	98/09/27	98/09/27	98/09/27	98/09/27

Batch Code:	**0927FB01**	**0927FB01**
2,3,7,8-TCDF (DB225)	043156 98	043158 98
	043157 98	043159 98
		043160 98
		043163 98
		043164 98
		043165 98
		043166 98
		043161 98
Run Date	98/10/20	98/10/20
Date of Sample Prep	98/09/27	98/09/27

PASC - Certificate of Analysis

Client ID:		Method Blank	Blank Spike #1	Blank Spike #1	Blank Spike #2	Blank Spike #2	R4M23-TB	R1M23 Baghouse Inlet
Lab No.:		043156 98	043156 98	043156 98	043156 98	043156 98	043157 98	043158 98
Date Sampled:		98/08/26	98/08/26	98/08/26	98/08/26	98/08/26	98/08/26	98/08/26
Component	Units			% Recoveries		% Recoveries		
Chlorobiphenyls	ug	<0.0090	0.83	100	0.89	110	<0.018	<0.073
Dichlorobiphenyls	"	<0.016	0.95	120	0.94	120	<0.016	<0.13
Trichlorobiphenyls	"	<0.013	0.78	98	0.84	100	<0.013	0.23
Tetrachlorobiphenyls	"	<0.021	0.74	92	0.74	93	<0.028	0.76
Pentachlorobiphenyls	"	<0.041	0.79	98	0.75	94	<0.036	0.23
Hexachlorobiphenyls	"	<0.023	0.75	94	0.75	94	<0.025	<0.038
Heptachlorobiphenyls	"	<0.021	0.74	92	0.75	93	<0.037	<0.034
Octachlorobiphenyls	"	<0.078	0.80	100	0.90	110	<0.053	<0.048
Nonachlorobiphenyls	"	<0.028	1.00	120	0.77	96	<0.019	<0.018
Decachlorobiphenyl	"	<0.028	0.82	100	0.84	100	<0.024	<0.022
PCB (total)	"	<0.0090	8.2	100	8.2	100	<0.013	1.2
Internal Recoveries	%							
4-Chlorobiphenyl-13C6		87	94	94	86	86	87	102
3,3,5,5-Tetrachlorobiphenyl-13C12		97	110	110	105	105	112	116
2,2,3,3,5,5,6,6-Octachlorobiphenyl-13C12		75	85	85	103	103	110	115
Decachlorobiphenyl-13C12		92	104	104	104	96	109	111
Surrogate Recoveries	%							
2,2,3,4,5,5,6-Heptachlorobiphenyl-13C12		NS	NS	-	NS	-	3.0	100

		R2M23 Baghouse Inlet	R3M23 Baghouse Inlet	R1M23 Cot Outlet
Client ID:				
Lab No.:		043159 98	043160 98	043161 98
Date Sampled:		98/08/26	98/08/26	98/08/26
Component	Units			
Chlorobiphenyls	ug	<0.040	<0.021	<0.017
Dichlorobiphenyls	"	0.088	<0.019	<0.015
Trichlorobiphenyls	"	<0.016	<0.030	<0.018
Tetrachlorobiphenyls	"	<0.053	<0.035	<0.054
Pentachlorobiphenyls	"	<0.034	<0.031	<0.028
Hexachlorobiphenyls	"	0.030	<0.031	<0.021
Heptachlorobiphenyls	"	<0.017	<0.035	<0.018
Octachlorobiphenyls	"	<0.11	<0.043	<0.066
Nonachlorobiphenyls	"	<0.038	<0.021	<0.027
Decachlorobiphenyl	"	<0.022	<0.021	<0.023
PCB (total)	"	0.12	<0.019	<0.015
Internal Recoveries	%			
4-Chlorobiphenyl-13C6		97	91	99
3,3,5,5-Tetrachlorobiphenyl-13C12		117	115	123
2,2,3,3,5,5,6,6-Octachlorobiphenyl-13C12		84	100	85
Decachlorobiphenyl-13C12		115	119	118
Surrogate Recoveries	%			
2,2,3,4,5,5,6-Heptachlorobiphenyl-13C12		101	103	5.0

00729

0010
MMS

PHILIP SERVICES

Certificate of Analysis

CLIENT INFORMATION		LABORATORY INFORMATION	
Attention:	Dan Cartner	**Contact:**	Ron McLeod
Client Name:	Best Environmental Inc.	**Project:**	AN980845
Project:	Livermore	**Date Received:**	98/08/28
Project Desc:	Stack Emissions	**Date Reported:**	98/10/14
Address:	15890 Foothill Blvd San Leandro,CA CA 94578	**Submission No.:**	8I0098
		Sample No.:	043156-043161
Fax Number:	510 278 4018		
Phone Number:	510 278 4011		

NOTES: *"-' = not analysed '<' = less than Method Detection Limit (MDL) 'NA' = no data available*
LOQ can by determined for all analytes by multiplying the appropriate MDL X 3.33
Solids data is based on dry weight except for biota analyses.
Organic analyses are not corrected for extraction recovery standards except for isotope dilution methods, (i.e. CARB 429 PAH, all PCDD/F and DBD/DBF analyses)

Methods used by PASC are based upon those found in 'Standard Methods for the Examination of Water and Wastewater', Nineteenth Edition. Other methods are based on the principles of MISA or EPA methodologies. New York State: ELAP Identification Number 10756.

All work recorded herein has been done in accordance with normal professional standards using accepted testing methodologies, quality assurance and quality control procedures except where otherwise agreed to by the client and testing company in writing. Any and all use of these test results shall be limited to the actual cost of the pertinent analysis done. There is no other warranty expressed or implied. Your samples will be retained at PASC for a period of three weeks from receipt of data or as per contract.

COMMENTS:

NS=Not Spiked

Certified by:

000084

5555 North Service Road, Burlington, Ontario, Canada L7L 5H7 Tel: 905 332-0700 Fax: 905 332-2508

			Method	Blank	Blank	Blank	Blank
	Client ID:		Blank	Spike #1	Spike #1	Spike #2	Spike #2
	Lab No.:		043156 98	043156 98	043156 98	043156 98	043156 98
	Date Sampled:		98/08/26	98/08/26	98/08/26	98/08/26	98/08/26
Component	**MDL**	**Units**			% Recoveries		% Recoveries
Aniline	10.0	ug	<40	<40	NS	<40	NS
Phenol	0.3	"	<1.2	120	60	130	64
Bis(2-chloroethyl)ether	0.8	"	<3.2	<3.2	NS	<3.2	NS
2-Chlorophenol	0.5	"	<2.0	150	74	160	79
1,3-Dichlorobenzene	1.5	"	<6.0	<6.0	NS	<6.0	NS
1,4-Dichlorobenzene	1.5	"	<6.0	75	75	76	76
1,2-Dichlorobenzene	1.7	"	<6.8	<6.8	NS	<6.8	NS
2-Methylphenol	1.2	"	<4.8	<4.8	NS	<4.8	NS
Bis(2-chloroisopropyl)ether	1.1	"	<4.4	<4.4	NS	<4.4	NS
4-Methylphenol	1.6	"	<6.4	<6.4	NS	<6.4	NS
N-Nitroso-di-N-Propylamine	1.1	"	<4.4	51	51	55	55
Hexachloroethane	1.1	"	<4.4	<4.4	NS	<4.4	NS
Nitrobenzene	0.8	"	<3.2	<3.2	NS	<3.2	NS
Isophorone	1.0	"	<4.0	<4.0	NS	<4.0	NS
2-Nitrophenol	1.2	"	<4.8	<4.8	NS	<4.8	NS
2,4-Dimethylphenol	10.0	"	<40	<40	NS	<40	NS
Bis(2-chloroethoxy)methane	1.2	"	<4.8	<4.8	NS	<4.8	NS
2,4-Dichlorophenol	1.2	"	<4.8	<4.8	NS	<4.8	NS
1,2,4-Trichlorobenzene	2.2	"	<8.8	82	82	82	NS
Naphthalene	1.9	"	<7.6	<7.6	NS	<7.6	NS
4-Chloroaniline	10.0	"	<40	<40	NS	<40	NS
Hexachlorobutadiene	1.0	"	<4.0	<4.0	NS	<4.0	NS
4-Chloro-3-Methylphenol	1.4	"	<5.6	150	76	160	78
2-Methylnaphthalene	1.8	"	<7.2	<7.2	NS	<7.2	NS
Hexachlorocyclopentadiene	10	"	<40	<40	NS	<40	NS
2,4,6-Trichlorophenol	1.2	"	<4.8	<4.8	NS	<4.8	NS
2,4,5-Trichlorophenol	1.7	"	<6.8	<6.8	NS	<6.8	NS
2-Chloronaphthalene	2.2	"	<8.8	<8.8	NS	<8.8	NS
2-Nitroaniline	10.0	"	<40	<40	NS	<40	NS
Dimethyl phthalate	0.7	"	<2.8	<2.8	NS	<2.8	NS
Acenaphthylene	1.6	"	<6.4	<6.4	NS	<6.4	NS
2,6-Dinitrotoluene	1.0	"	<4.0	<4.0	NS	<4.0	NS
3-Nitroaniline	10	"	<40	<40	NS	<40	NS
Acenaphthene	2.0	"	<8.0	86	86	89	89
2,4-Dinitrophenol	10.0	"	<40	<40	NS	<40	NS
4-Nitrophenol	10.0	"	<40	140	72	150	75
Dibenzofuran	10.0	"	<40	<40	NS	<40	NS
2,4-Dinitrotoluene	1.1	"	<4.4	76	76	81	81
Diethyl phthalate	0.4	"	<1.6	<1.6	NS	<1.6	NS
4-Chlorophenylphenylether	1.8	"	<7.2	<7.2	NS	<7.2	NS
Fluorene	1.3	"	<5.2	<5.2	NS	<5.2	NS
4-Nitroaniline	10.0	"	<40	<40	NS	<40	NS
4,6-Dinitro-2-methylphenol	1.2	"	<4.8	<4.8	NS	<4.8	NS
N-Nitrosodiphenylamine	3.5	"	<14	<14	NS	<14	NS
4-Bromophenylphenylether	1.6	"	<6.4	<6.4	NS	<6.4	NS
Hexachlorobenzene	1.0	"	<4.0	<4.0	NS	<4.0	NS
Pentachlorophenol	1.5	"	<6.0	50	50	50	50
Phenanthrene	0.6	"	<2.4	<2.4	NS	<2.4	NS

			Method	Blank	Blank	Blank	Blank
	Client ID:		Blank	Spike #1	Spike #1	Spike #2	Spike #2
	Lab No.:		043156 98	043156 98	043156 98	043156 98	043156 98
	Date Sampled:		98/08/26	98/08/26	98/08/26	98/08/26	98/08/26
Component	**MDL**	**Units**			% Recoveries		% Recoveries
Anthracene	1.1	"	<4.4	<4.4	NS	<4.4	NS
Carbazole	0.3	"	<1.2	<1.2	NS	<1.2	NS
Di-n-butyl phthalate	1.0	"	<4.0	<4.0	NS	<4.0	NS
Fluoranthene	1.0	"	<4.0	<4.0	NS	<4.0	NS
Pyrene	0.5	"	1.4	87	87	90	90
Benzyl butyl phthalate	1.3	"	<5.2	<5.2	NS	<5.2	NS
3,3-Dichlorobenzidine	10.0	"	<40	<40	NS	<40	NS
Benzo(a)anthracene	0.8	"	<3.2	<3.2	NS	<3.2	NS
Chrysene	0.5	"	<2.0	<2.0	NS	<2.0	NS
Bis(2-ethylhexyl)phthalate	2.0	"	<8.0	<8.0	NS	<8.0	NS
Di-n-octyl phthalate	1.3	"	<5.2	<5.2	NS	<5.2	NS
Benzo(b)fluoranthene	1.0	"	<4.0	<4.0	NS	<4.0	NS
Benzo(k)fluoranthene	1.1	"	<4.4	<4.4	NS	<4.4	NS
Benzo(a)pyrene	0.8	"	<3.2	<3.2	NS	<3.2	NS
Indeno(1,2,3-cd)pyrene	0.6	"	<2.4	<2.4	NS	<2.4	NS
Dibenzo(a,h)anthracene	1.0	"	<4.0	<4.0	NS	<4.0	NS
Benzo(ghi)perylene	0.7	"	<2.8	<2.8	NS	<2.8	NS
Surrogate Recoveries		%					
2-Fluorophenol			56	-	55	-	63
d5-Phenol			64	-	68	-	75
d5-Nitrobenzene			72	-	76	-	82
2-Fluorobiphenyl			93	-	92	-	100
2 4,6-Tribromophenol			81	-	83	-	92
d-14-p-Terphenyl			89	-	91	-	95
Field Spike		%					
2,6-Dibromo-4-fluorophenol			NS	NS	-	NS	-
d10-Pyrene			NS	NS	-	NS	-

	Client ID:		R4M23-TB	R1M23 Baghouse Inlet	R2M23 Baghouse Inlet	R3M23 Baghouse Inlet
	Lab No.:		043157 98	043158 98	043159 98	043160 98
	Date Sampled:		98/08/26	98/08/26	98/08/26	98/08/26
Component	**MDL**	**Units**				
Aniline	10.0	ug	<40	<40	<40	<40
Phenol	0.3	"	<1.2	<1.2	<1.2	<1.2
Bis(2-chloroethyl)ether	0.8	"	<3.2	<3.2	<3.2	<3.2
2-Chlorophenol	0.5	"	<2.0	<2.0	<2.0	<2.0
1,3-Dichlorobenzene	1.5	"	<6.0	<6.0	<6.0	<6.0
1,4-Dichlorobenzene	1.5	"	<6.0	<6.0	<6.0	<6.0
1,2-Dichlorobenzene	1.7	"	<6.8	<6.8	<6.8	<6.8
2-Methylphenol	1.2	"	<4.8	<4.8	<4.8	<4.8
Bis(2-chloroisopropyl)ether	1.1	"	<4.4	<4.4	<4.4	<4.4
4-Methylphenol	1.6	"	<6.4	<6.4	<6.4	<6.4
N-Nitroso-di-N-Propylamine	1.1	"	<4.4	<4.4	<4.4	<4.4
Hexachloroethane	1.1	"	<4.4	<4.4	<4.4	<4.4
Nitrobenzene	0.8	"	<3.2	<3.2	<3.2	<3.2
Isophorone	1.0	"	<4.0	<4.0	<4.0	<4.0
2-Nitrophenol	1.2	"	<4.8	<4.8	<4.8	<4.8
2,4-Dimethylphenol	10.0	"	<40	<40	<40	<40
Bis(2-chloroethoxy)methane	1.2	"	<4.8	<4.8	<4.8	<4.8
2,4-Dichlorophenol	1.2	"	<4.8	<4.8	<4.8	<4.8
1,2,4-Trichlorobenzene	2.2	"	<8.8	<8.8	<8.8	<8.8
Naphthalene	1.9	"	<7.6	<7.6	<7.6	<7.6
4-Chloroaniline	10.0	"	<40	<40	<40	<40
Hexachlorobutadiene	1.0	"	<4.0	<4.0	<4.0	<4.0
4-Chloro-3-Methylphenol	1.4	"	<5.6	<5.6	<5.6	<5.6
2-Methylnaphthalene	1.8	"	<7.2	<7.2	<7.2	<7.2
Hexachlorocyclopentadiene	10	"	<40	<40	<40	<40
2,4,6-Trichlorophenol	1.2	"	<4.8	<4.8	<4.8	<4.8
2,4,5-Trichlorophenol	1.7	"	<6.8	<6.8	<6.8	<6.8
2-Chloronaphthalene	2.2	"	<8.8	<8.8	<8.8	<8.8
2-Nitroaniline	10.0	"	<40	<40	<40	<40
Dimethyl phthalate	0.7	"	<2.8	<2.8	<2.8	<2.8
Acenaphthylene	1.6	"	<6.4	<6.4	<6.4	<6.4
2,6-Dinitrotoluene	1.0	"	<4.0	<4.0	<4.0	<4.0
3-Nitroaniline	10	"	<40	<40	<40	<40
Acenaphthene	2.0	"	<8.0	<8.0	<8.0	<8.0
2,4-Dinitrophenol	10.0	"	<40	<40	<40	<40
4-Nitrophenol	10.0	"	<40	<40	<40	<40
Dibenzofuran	10.0	"	<40	<40	<40	<40
2,4-Dinitrotoluene	1.1	"	<4.4	<4.4	<4.4	<4.4
Diethyl phthalate	0.4	"	<1.6	150	1.9	<1.6
4-Chlorophenylphenylether	1.8	"	<7.2	<7.2	<7.2	<7.2
Fluorene	1.3	"	<5.2	<5.2	<5.2	<5.2
4-Nitroaniline	10.0	"	<40	<40	<40	<40
4,6-Dinitro-2-methylphenol	1.2	"	<4.8	<4.8	<4.8	<4.8
N-Nitrosodiphenylamine	3.5	"	<14	<14	<14	<14
4-Bromophenylphenylether	1.6	"	<6.4	<6.4	<6.4	<6.4
Hexachlorobenzene	1.0	"	<4.0	<4.0	<4.0	<4.0
Pentachlorophenol	1.5	"	<6.0	<6.0	<6.0	<6.0
Phenanthrene	0.6	"	<2.4	4.5	2.5	<2.4

PASC - Certificate of Analysis

	Client ID:		R4M23-TB	R1M23 Baghouse Inlet	R2M23 Baghouse Inlet	R3M23 Baghouse Inlet
	Lab No.:		043157 98	043158 98	043159 98	043160 98
	Date Sampled:		98/08/26	98/08/26	98/08/26	98/08/26
Component	**MDL**	**Units**				
Anthracene	1.1	"	<4.4	<4.4	<4.4	<4.4
Carbazole	0.3	"	<1.2	<1.2	<1.2	<1.2
Di-n-butyl phthalate	1.0	"	<4.0	18	4.0	<4.0
Fluoranthene	1.0	"	<4.0	<4.0	<4.0	<4.0
Pyrene	0.5	"	<2.0	<2.0	<2.0	<2.0
Benzyl butyl phthalate	1.3	"	<5.2	<5.2	<5.2	<5.2
3,3-Dichlorobenzidine	10.0	"	<40	<40	<40	<40
Benzo(a)anthracene	0.8	"	<3.2	<3.2	<3.2	<3.2
Chrysene	0.5	"	<2.0	<2.0	<2.0	<2.0
Bis(2-ethylhexyl)phthalate	2.0	"	<8.0	15	23	11
Di-n-octyl phthalate	1.3	"	<5.2	<5.2	<5.2	<5.2
Benzo(b)fluoranthene	1.0	"	<4.0	<4.0	<4.0	<4.0
Benzo(k)fluoranthene	1.1	"	<4.4	<4.4	<4.4	<4.4
Benzo(a)pyrene	0.8	"	<3.2	<3.2	<3.2	<3.2
Indeno(1,2,3-cd)pyrene	0.6	"	<2.4	<2.4	<2.4	<2.4
Dibenzo(a,h)anthracene	1.0	"	<4.0	<4.0	<4.0	<4.0
Benzo(ghi)perylene	0.7	"	<2.8	<2.8	<2.8	<2.8
Surrogate Recoveries		%				
2-Fluorophenol			79	81	85	78
d5-Phenol			88	94	86	82
d5-Nitrobenzene			77	75	73	69
2-Fluorobiphenyl			94	93	91	88
2,4,6-Tribromophenol			67	66	83	81
d14-p-Terphenyl			91	94	92	91
Field Spike		%				
2,6-Dibromo-4-fluorophenol			40	52	92	79
d10-Pyrene			83	116	108	111

PASC - Certificate of Analysis

			R1M23 Cot	R1M429	R2M429	R3M429	R1M429 Cat
	Client ID:		Outlet	BaghouseInlet	BaghouseInlet	BaghouseInlet	Outlet
	Lab No.:		043161 98	043163 98	043164 98	043165 98	043166 98
	Date Sampled:		98/08/26	98/08/18	98/08/18	98/08/19	98/08/18
Component	**MDL**	**Units**					
Aniline	10.0	ug	<40	<40	<40	<40	<40
Phenol	0.3	"	8.7	<4.5	<1.2	<1.2	<1.2
Bis(2-chloroethyl)ether	0.8	"	<3.2	<3.2	<3.2	<3.2	<3.2
2-Chlorophenol	0.5	"	<2.0	<2.0	<2.0	<2.0	<2.0
1,3-Dichlorobenzene	1.5	"	<6.0	<6.0	<6.0	<6.0	<6.0
1,4-Dichlorobenzene	1.5	"	<6.0	<6.0	<6.0	<6.0	<6.0
1,2-Dichlorobenzene	1.7	"	<6.8	<6.8	<6.8	<6.8	<6.8
2-Methylphenol	1.2	"	<4.8	<4.8	<4.8	<4.8	<4.8
Bis(2-chloroisopropyl)ether	1.1	"	<4.4	<4.4	<4.4	<4.4	<4.4
4-Methylphenol	1.6	"	<6.4	<6.4	<6.4	<6.4	<6.4
N-Nitroso-di-N-Propylamine	1.1	"	<4.4	<4.4	<4.4	<4.4	<4.4
Hexachloroethane	1.1	"	<4.4	<4.4	<4.4	<4.4	<4.4
Nitrobenzene	0.8	"	<3.2	<3.2	<3.2	<3.2	<3.2
Isophorone	1.0	"	<4.0	<4.0	<4.0	<4.0	<4.0
2-Nitrophenol	1.2	"	<4.8	<4.8	<4.8	<4.8	9.7
2,4-Dimethylphenol	10.0	"	<40	<40	<40	<40	<40
Bis(2-chloroethoxy)methane	1.2	"	<4.8	<4.8	<4.8	<4.8	<4.8
2,4-Dichlorophenol	1.2	"	<4.8	<4.8	<4.8	<4.8	<4.8
1,2,4-Trichlorobenzene	2.2	"	<8.8	<8.8	<8.8	<8.8	<8.8
Naphthalene	1.9	"	<7.6	<7.6	<7.6	<7.6	<7.6
4-Chloroaniline	10.0	"	<40	<40	<40	<40	<40
Hexachlorobutadiene	1.0	"	<4.0	<4.0	<4.0	<4.0	<4.0
4-Chloro-3-Methylphenol	1.4	"	<5.6	<5.6	<5.6	<5.6	<5.6
2-Methylnaphthalene	1.8	"	<7.2	<7.2	<7.2	<7.2	<7.2
Hexachlorocyclopentadiene	10	"	<40	<40	<40	<40	<40
2,4,6-Trichlorophenol	1.2	"	<4.8	<4.8	<4.8	<4.8	<4.8
2,4,5-Trichlorophenol	1.7	"	<6.8	<6.8	<6.8	<6.8	<6.8
2-Chloronaphthalene	2.2	"	<8.8	<8.8	<8.8	<8.8	<8.8
2-Nitroaniline	10.0	"	<40	<40	<40	<40	<40
Dimethyl phthalate	0.7	"	<2.8	<2.8	<2.8	<2.8	<2.8
Acenaphthylene	1.6	"	<6.4	<6.4	<6.4	<6.4	<6.4
2,6-Dinitrotoluene	1.0	"	<4.0	<4.0	<4.0	<4.0	<4.0
3-Nitroaniline	10	"	<40	<40	<40	<40	<40
Acenaphthene	2.0	"	<8.0	<8.0	<8.0	<8.0	<8.0
2,4-Dinitrophenol	10.0	"	<40	<40	<40	<40	<40
4-Nitrophenol	10.0	"	<40	<40	<40	<40	<40
Dibenzofuran	10.0	"	<40	<40	<40	<40	<40
2,4-Dinitrotoluene	1.1	"	<4.4	<4.4	<4.4	<4.4	<4.4
Diethyl phthalate	0.4	"	<1.6	9.9	13	3.1	<1.6
4-Chlorophenylphenylether	1.8	"	<7.2	<7.2	<7.2	<7.2	<7.2
Fluorene	1.3	"	<5.2	<5.2	<5.2	<5.2	<5.2
4-Nitroaniline	10.0	"	<40	<40	<40	<40	<40
4,6-Dinitro-2-methylphenol	1.2	"	<4.8	<4.8	<4.8	<4.8	<4.8
N-Nitrosodiphenylamine	3.5	"	<14	<14	<14	<14	<14
4-Bromophenylphenylether	1.6	"	<6.4	<6.4	<6.4	<6.4	<6.4
Hexachlorobenzene	1.0	"	<4.0	<4.0	<4.0	<4.0	<4.0
Pentachlorophenol	1.5	"	<6.0	<6.0	<6.0	<6.0	<6.0
Phenanthrene	0.6	"	<2.4	19	3.7	4.0	<2.4

	Client ID:		R1M23 Cot Outlet	R1M429 BaghouseInlet	R2M429 BaghouseInlet	R3M429 BaghouseInlet	R1M429 Cat Outlet
	Lab No.:		043161 98	043163 98	043164 98	043165 98	043166 98
	Date Sampled:		98/08/26	98/08/18	98/08/18	98/08/19	98/08/18
Component	**MDL**	**Units**					
Anthracene	1.1	"	<4.4	<4.4	<4.4	<4.4	<4.4
Carbazole	0.3	"	<1.2	<1.2	<1.2	<1.2	<1.2
Di-n-butyl phthalate	1.0	"	<4.0	31	21	9.8	<4.0 •
Fluoranthene	1.0	"	<4.0	16	<4.0	<4.0	<4.0 •
Pyrene	0.5	"	<2.0	9.3	<2.0	<2.0	<2.0 •
Benzyl butyl phthalate	1.3	"	<5.2	<5.2	<5.2	<5.2	<5.2
3,3-Dichlorobenzidine	10.0	"	<40	<40	<40	<40	<40
Benzo(a)anthracene	0.8	"	<3.2	<3.2	<3.2	<3.2	<3.2
Chrysene	0.5	"	<2.0	2.0	<2.0	<2.0	<2.0 •
Bis(2-ethylhexyl)phthalate	2.0	"	<8.0	21	19	25	11 •
Di-n-octyl phthalate	1.3	"	<5.2	<5.2	<5.2	<5.2	<5.2
Benzo(b)fluoranthene	1.0	"	<4.0	<4.0	<4.0	<4.0	<4.0
Benzo(k)fluoranthene	1.1	"	<4.4	<4.4	<4.4	<4.4	<4.4
Benzo(a)pyrene	0.8	"	<3.2	<3.2	<3.2	<3.2	<3.2
Indeno(1,2,3-cd)pyrene	0.6	"	<2.4	<2.4	<2.4	<2.4	<2.4
Dibenzo(a,h)anthracene	1.0	"	<4.0	<4.0	<4.0	<4.0	<4.0
Benzo(ghi)perylene	0.7	"	<2.8	<2.8	<2.8	<2.8	<2.8
Surrogate Recoveries		%					
2-Fluorophenol			51	88	84	89	69
d5-Phenol			66	90	88	90	92
d5-Nitrobenzene			70	80	77	82	78
2-Fluorobiphenyl			87	95	94	94	88
2,4,6-Tribromophenol			88	90	91	91	83
d-14-p-Terphenyl			91	89	93	92	84
Field Spike		%					
2,6-Dibromo-4-fluorophenol			41	71	75	69	32
110-Pyrene			81	83	86	85	73

		Method	Blank	Blank	Blank	Blank		R1M23 Baghouse
Client ID:		Blank	Spike #1	Spike #1	Spike #2	Spike #2	R4M23-TB	Inlet
Lab No.:		043156 98	043156 98	043156 98	043156 98	043156 98	043157 98	043158 98
Date Sampled:		98/08/26	98/08/26	98/08/26	98/08/26	98/08/26	98/08/26	98/08/26
Component	Units			% Recoveries		% Recoveries		
Chlorobiphenyls	ug	<0.0090	0.83	100	0.89	110	<0.018	<0.073
Dichlorobiphenyls	"	<0.016	0.95	120	0.94	120	<0.016	<0.13
Trichlorobiphenyls	"	<0.013	0.78	98	0.84	100	<0.013	0.23
Tetrachlorobiphenyls	"	<0.021	0.74	92	0.74	93	<0.028	0.76
Pentachlorobiphenyls	"	<0.041	0.79	98	0.75	94	<0.036	0.23
Hexachlorobiphenyls	"	<0.023	0.75	94	0.75	94	<0.025	<0.038
Heptachlorobiphenyls	"	<0.021	0.74	92	0.75	93	<0.037	<0.034
Octachlorobiphenyls	"	<0.078	0.80	100	0.90	110	<0.053	<0.048
Nonachlorobiphenyls	"	<0.028	1.00	120	0.77	96	<0.019	<0.018
Decachlorobiphenyl	"	<0.028	0.82	100	0.84	100	<0.024	<0.022
PCB (total)	"	<0.0090	8.2	100	8.2	100	<0.013	1.2
Internal Recoveries	%							
4-Chlorobiphenyl-13C6		87	94	94	86	86	87	102
3,3,5,5-Tetrachlorobiphenyl-13C12		97	110	110	105	105	112	116
2,2,3,3,5,5,6,6-Octachlorobiphenyl-13C12		75	85	85	103	103	110	115
Decachlorobiphenyl-13C12		92	104	104	104	96	109	111
Surrogate Recoveries	%							
2,2,3,4,5,5,6-Heptachlorobiphenyl-13C12		NS	NS	-	NS	-	3.0	100

PASC - Certificate of Analysis

Component	Client ID: / Lab No.: / Date Sampled:	Units	R2M23 Baghouse Inlet 043159 98 98/08/26	R3M23 Baghouse Inlet 043160 98 98/08/26	R1M23 Cot Outlet 043161 98 98/08/26
Chlorobiphenyls		ug	<0.040	<0.021	<0.017
Dichlorobiphenyls		"	0.088	<0.019	<0.015
Trichlorobiphenyls		"	<0.016	<0.030	<0.018
Tetrachlorobiphenyls		"	<0.053	<0.035	<0.054
Pentachlorobiphenyls		"	<0.034	<0.031	<0.028
Hexachlorobiphenyls		"	0.030	<0.031	<0.021
Heptachlorobiphenyls		"	<0.017	<0.035	<0.018
Octachlorobiphenyls		"	<0.11	<0.043	<0.066
Nonachlorobiphenyls		"	<0.038	<0.021	<0.027
Decachlorobiphenyl		"	<0.022	<0.021	<0.023
PCB (total)		"	0.12	<0.019	<0.015
Internal Recoveries		%			
4-Chlorobiphenyl-13C6			97	91	99
3,3,5,5-Tetrachlorobiphenyl-13C12			117	115	123
2,2,3,3,5,5,6,6-Octachlorobiphenyl-13C12			84	100	85
Decachlorobiphenyl-13C12			115	119	118
Surrogate Recoveries		%			
2,2,3,4,5,5,6-Heptachlorobiphenyl-13C12			101	103	5.0

Batch Code:	**0927FB01**
SVOC	043156 98
	043157 98
	043158 98
	043159 98
	043160 98
	043161 98
	043163 98
	043164 98
	043165 98
	043166 98
Run Date	98/01/05
Date of Sample Prep	98/09/27

Batch Code:	**0927FB01**
PCB	043156 98
	043157 98
	043158 98
	043159 98
	043160 98
	043161 98
Run Date	98/10/05
Date of Sample Prep	98/09/27

01319

PHILIP SERVICES

VOST
0030

Certificate of Analysis

CLIENT INFORMATION		LABORATORY INFORMATION	
Attention:	Dan Cartner	**Contact:**	Ron McLeod
Client Name:	Best Environmental Inc.	**Project:**	AN980845
Project:	Livermore	**Date Received:**	98/08/28
Project Desc:	Stack Emissions	**Date Reported:**	98/09/16
Address:	15890 Foothill Blvd San Leandro,CA CA 94578	**Submission No.:**	8I0098
		Sample No.:	043187-043213
Fax Number:	510 278 4018		
Phone Number:	510 278 4011		

NOTES: *"-' = not analysed '<' = less than Method Detection Limit (MDL) 'NA' = no data available*
LOQ can by determined for all analytes by multiplying the appropriate MDL X 3.33
Solids data is based on dry weight except for biota analyses.
Organic analyses are not corrected for extraction recovery standards except for isotope dilution methods. (i.e. CARB 429 PAH, all PCDD/F and DBD/DBF analyses)

Methods used by PASC are based upon those found in 'Standard Methods for the Examination of Water and Wastewater', Nineteenth Edition. Other methods are based on the principles of MISA or EPA methodologies. New York State: ELAP Identification Number 10756.

All work recorded herein has been done in accordance with normal professional standards using accepted testing methodologies, quality assurance and quality control procedures except where otherwise agreed to by the client and testing company in writing. Any and all use of these test results shall be limited to the actual cost of the pertinent analysis done. There is no other warranty expressed or implied. Your samples will be retained at PASC for a period of three weeks from receipt of data or as per contract.

COMMENTS: **Revised Report: 981001**

*Estimated value, data above the instrument calibration range. Sample contamination with dichloromethane and acetone is almost certainly related to cross-contamination of the traps with SVOC train solvents shipped in the same container as the VOST samples. Most of the response from these analytes is likely not from the stack source.
**Data uncorrected for recovery of the first internal standard (bromochloromethane, BCM) because of interference from a cyclic C-5 hydrocarbon (likely methylcyclopentane) the BCM peak being suppressed from interference from this peak.
***Data uncorrected for recovery of the first internal standard because of poor recovery of this internal standard.

Certified by:

PASC - Certificate of Analysis

			LLNL Field Blank	LLNL Trip Blank	RTS#1/R1/0030 15a/b	RTS#1/R1/0030 2a/b
	Client ID:					
	Lab No.:		043187 98	043188 98	043189 98	043190 98
	Date Sampled:		98/08/18	98/08/18	98/08/18	98/08/18
Component	**MDL**	**Units**				
Chloromethane	0.007	ug	0.053	<	<	0.23
Bromomethane	0.005	"	0.042	<	0.039	0.10
Vinyl Chloride	0.013	"	<	<	<	<
Chloroethane	0.007	"	<	<	<	<
Methylene Chloride	0.019	"	3.2*	0.54	3.5*	3.3*
Acetone	0.045	"	0.41	<	1.5*	2.4*
Carbon Disulfide	0.018	"	<	<	<	<
1,1-Dichloroethene	0.007	"	0.036	<	0.14	0.082
1,1-Dichloroethane	0.004	"	<	<	<	<
1,2-Dichloroethene(total)	0.007	"	<	<	<	<
Chloroform	0.008	"	<	<	<	<
1,2-Dichloroethane	0.006	"	<	<	<	<
2-Butanone	0.036	"	<	<	<	<
1,1,1-Trichloroethane	0.014	"	<	<	0.083	0.035
Carbon Tetrachloride	0.016	"	<	<	<	<
Bromodichloromethane	0.011	"	<	<	<	<
1,2-Dichloropropane	0.008	"	<	<	<	<
cis-1,3-Dichloropropene	0.007	"	<	<	<	<
Trichloroethene	0.009	"	<	<	<	<
Dibromochlormethane	0.008	"	<	<	<	<
1,1,2-Trichloroethane	0.016	"	<	<	<	<
Benzene	0.009	"	0.018	0.009	0.034	0.057
trans-1,3-Dichloropropene	0.007	"	<	<	<	<
Bromoform	0.012	"	<	<	<	<
4-Methyl-2-Pentanone	0.019	"	<	<	<	<
2-Hexanone	0.031	"	<	<	<	<
Tetrachloroethene	0.008	"	<	<	0.008	<
1,1,2,2-Tetrachloroethane	0.014	"	<	<	<	<
Toluene	0.009	"	0.019	<	0.17	0.088
Chlorobenzene	0.009	"	<	<	<	<
Ethylbenzene	0.006	"	<	<	0.010	0.007
Styrene	0.007	"	<	<	0.018	0.007
Xylene(total)	0.015	"	<	<	0.049	0.044
1,1,2-Trichlorotrifluoroethane	0.020	"	<	<	<	<
Surrogate Recoveries		%				
d4-1,2-Dichloroethane			107	95	105	109
d8-Toluene			99	100	98	98
Bromofluorobenzene			109	113	114	105
Field Spike		%				
d10-Ethylbenzene			99	92	98	99

			RTS#1/R1/0030	RTS#1/R2/0030	RTS#1/R2/0030
	Client ID:		3a/b	4a/b	5a/b
	Lab No.:		043191 98	043192 98	043193 98
	Date Sampled:		98/08/18	98/08/18	98/08/18
Component	**MDL**	**Units**			
Chloromethane	0.007	ug	0.089	<	0.33
Bromomethane	0.005	"	0.052	0.029	<
Vinyl Chloride	0.013	"	<	<	<
Chloroethane	0.007	"	<	<	<
Methylene Chloride	0.019	"	3.1*	2.9*	1.9*
Acetone	0.045	"	3.5*	4.3*	4.1*
Carbon Disulfide	0.018	"	<	<	<
1,1-Dichloroethene	0.007	"	0.046	0.055	0.019
1,1-Dichloroethane	0.004	"	<	<	<
1,2-Dichloroethene(total)	0.007	"	<	<	<
Chloroform	0.008	"	<	<	<
1,2-Dichloroethane	0.006	"	<	<	<
2-Butanone	0.036	"	<	<	<
1,1,1-Trichloroethane	0.014	"	0.019	<	<
Carbon Tetrachloride	0.016	"	<	<	<
Bromodichloromethane	0.011	"	<	<	<
1,2-Dichloropropane	0.008	"	<	<	0.15
cis-1,3-Dichloropropene	0.007	"	<	<	<
Trichloroethene	0.009	"	<	<	<
Dibromochlormethane	0.008	"	<	<	<
1,1,2-Trichloroethane	0.016	"	<	<	<
Benzene	0.009	"	0.033	0.039	0.035
trans-1,3-Dichloropropene	0.007	"	<	<	<
Bromoform	0.012	"	<	<	<
4-Methyl-2-Pentanone	0.019	"	<	<	<
2-Hexanone	0.031	"	<	<	<
Tetrachloroethene	0.008	"	<	<	<
1,1,2,2-Tetrachloroethane	0.014	"	<	<	<
Toluene	0.009	"	0.034	0.25	0.21
Chlorobenzene	0.009	"	<	<	<
Ethylbenzene	0.006	"	0.006	0.006	<
Styrene	0.007	"	<	0.008	<
Xylene(total)	0.015	"	0.033	0.034	0.022
1,1,2-Trichlorotrifluoroethane	0.020	"	<	<	<
Surrogate Recoveries		%			
d4-1,2-Dichloroethane			108	106	102
d8-Toluene			98	101	96
Bromofluorobenzene			114	112	106
Field Spike		%			
110-Ethylbenzene			99	100	97

			RTS#1/R2/0030	RTS#1/R3/0030	RTS#1/R3/0030
	Client ID:		6a/b	8a/b	9a/b
	Lab No.:		043194 98	043195 98	043196 98
	Date Sampled:		98/08/18	98/08/18	98/08/18
Component	**MDL**	**Units**			
Chloromethane	0.007	ug	<	2.9	0.48
Bromomethane	0.005	"	<	0.054	<
Vinyl Chloride	0.013	"	<	<	<
Chloroethane	0.007	"	<	<	<
Methylene Chloride	0.019	"	1.8*	2.0*	0.21
Acetone	0.045	"	3.4*	0.20	0.74
Carbon Disulfide	0.018	"	<	<	<
1,1-Dichloroethene	0.007	"	0.032	0.028	<
1,1-Dichloroethane	0.004	"	<	<	<
1,2-Dichloroethene(total)	0.007	"	<	<	<
Chloroform	0.008	"	<	<	<
1,2-Dichloroethane	0.006	"	<	<	<
2-Butanone	0.036	"	0.19	<	<
1,1,1-Trichloroethane	0.014	"	0.016	<	<
Carbon Tetrachloride	0.016	"	<	<	<
Bromodichloromethane	0.011	"	<	<	<
1,2-Dichloropropane	0.008	"	<	<	<
cis-1,3-Dichloropropene	0.007	"	<	<	<
Trichloroethene	0.009	"	<	<	<
Dibromochlormethane	0.008	"	<	<	<
1,1,2-Trichloroethane	0.016	"	<	<	<
Benzene	0.009	"	0.033	0.035	0.030
trans-1,3-Dichloropropene	0.007	"	<	<	<
Bromoform	0.012	"	<	<	<
4-Methyl-2-Pentanone	0.019	"	<	<	<
2-Hexanone	0.031	"	<	<	<
Tetrachloroethene	0.008	"	<	<	<
1,1,2,2-Tetrachloroethane	0.014	"	<	<	<
Toluene	0.009	"	0.17	0.11	0.40
Chlorobenzene	0.009	"	<	<	<
Ethylbenzene	0.006	"	<	<	<
Styrene	0.007	"	<	<	<
Xylene(total)	0.015	"	0.021	0.019	0.021
1,1,2-Trichlorotrifluoroethane	0.020	"	<	<	<
Surrogate Recoveries		%			
d4-1,2-Dichloroethane			103	109	108
d8-Toluene			98	95	99
Bromofluorobenzene			112	100	86
Field Spike		%			
d10-Ethylbenzene			98	99	96

			RTS#1/R3/0030	RTS#1/R1CAT	RTS#1/R1CAT
	Client ID:		10a/b	11a/b	13a/b
	Lab No.:		043197 98	043198 98	043199 98
	Date Sampled:		98/08/18	98/08/18	98/08/18
Component	**MDL**	**Units**			
Chloromethane	0.007	ug	0.56	0.074	0.052
Bromomethane	0.005	"	0.042	0.022	0.092
Vinyl Chloride	0.013	"	<	<	<
Chloroethane	0.007	"	<	<	<
Methylene Chloride	0.019	"	2.0*	1.4*	1.1*
Acetone	0.045	"	0.61	<	0.41
Carbon Disulfide	0.018	"	<	<	<
1,1-Dichloroethene	0.007	"	0.036	0.13	0.012
1,1-Dichloroethane	0.004	"	<	<	<
1,2-Dichloroethene(total)	0.007	"	<	<	<
Chloroform	0.008	"	<	<	<
1,2-Dichloroethane	0.006	"	<	<	<
2-Butanone	0.036	"	<	<	<
1,1,1-Trichloroethane	0.014	"	<	0.25	<
Carbon Tetrachloride	0.016	"	<	<	<
Bromodichloromethane	0.011	"	<	<	<
1,2-Dichloropropane	0.008	"	<	<	<
cis-1,3-Dichloropropene	0.007	"	<	<	<
Trichloroethene	0.009	"	<	<	<
Dibromochlormethane	0.008	"	<	<	<
1,1,2-Trichloroethane	0.016	"	<	<	<
Benzene	0.009	"	0.027	0.080	0.14
trans-1,3-Dichloropropene	0.007	"	<	<	<
Bromoform	0.012	"	<	<	<
4-Methyl-2-Pentanone	0.019	"	<	<	<
2-Hexanone	0.031	"	<	<	<
Tetrachloroethene	0.008	"	<	0.041	<
1,1,2,2-Tetrachloroethane	0.014	"	<	<	<
Toluene	0.009	"	0.28	0.23	0.028
Chlorobenzene	0.009	"	<	<	<
Ethylbenzene	0.006	"	<	<	<
Styrene	0.007	"	<	<	<
Xylene(total)	0.015	"	0.021	0.021	0.016
1,1,2-Trichlorotrifluoroethane	0.020	"	<	<	<
Surrogate Recoveries		%			
d4-1,2-Dichloroethane			113	89	89
d8-Toluene			102	103	101
Bromofluorobenzene			111	103	58
Field Spike		%			
d10-Ethylbenzene			90	100	97

			RTS#1/R1CAT	LLNL Field	RTS#2/R1/0030
	Client ID:		14a/b	Blank	23a/b
	Lab No.:		043200 98	043201 98	043202 98
	Date Sampled:		98/08/18	98/08/18	98/08/26
Component	**MDL**	**Units**			
Chloromethane	0.007	ug	0.052	<	<
Bromomethane	0.005	"	0.058	0.009	0.035**
Vinyl Chloride	0.013	"	<	<	<
Chloroethane	0.007	"	<	<	<
Methylene Chloride	0.019	"	1.2*	0.21	1.0**
Acetone	0.045	"	0.42	<	0.56**
Carbon Disulfide	0.018	"	<	<	<
1,1-Dichloroethene	0.007	"	<	<	<
1,1-Dichloroethane	0.004	"	<	<	<
1,2-Dichloroethene(total)	0.007	"	<	<	<
Chloroform	0.008	"	<	<	<
1,2-Dichloroethane	0.006	"	<	<	<
2-Butanone	0.036	"	<	<	<
1,1,1-Trichloroethane	0.014	"	<	<	<
Carbon Tetrachloride	0.016	"	<	<	<
Bromodichloromethane	0.011	"	<	<	<
1,2-Dichloropropane	0.008	"	<	<	<
cis-1,3-Dichloropropene	0.007	"	<	<	<
Trichloroethene	0.009	"	<	<	<
Dibromochlormethane	0.008	"	<	<	<
1,1,2-Trichloroethane	0.016	"	<	<	<
Benzene	0.009	"	0.10	0.015	0.29
trans-1,3-Dichloropropene	0.007	"	<	<	<
Bromoform	0.012	"	<	<	<
4-Methyl-2-Pentanone	0.019	"	<	<	<
2-Hexanone	0.031	"	<	<	0.076
Tetrachloroethene	0.008	"	<	<	<
1,1,2,2-Tetrachloroethane	0.014	"	<	<	<
Toluene	0.009	"	0.060	<	0.11
Chlorobenzene	0.009	"	<	<	<
Ethylbenzene	0.006	"	<	<	<
Styrene	0.007	"	<	<	0.007
Xylene(total)	0.015	"	<	<	0.027
1,1,2-Trichlorotrifluoroethane	0.020	"	<	<	<
Surrogate Recoveries		%			
d4-1,2-Dichloroethane			93	92	74
d8-Toluene			106	104	93
Bromofluorobenzene			97	108	107
Field Spike		%			
d10-Ethylbenzene			79	104	85

			RTS#2/R1/0030	RTS#2/R1/0030	RTS#2/R2/0030
	Client ID:		22a/b	21a/b	20a/b
	Lab No.:		043203 98	043204 98	043205 98
	Date Sampled:		98/08/26	98/08/26	98/08/26
Component	**MDL**	**Units**			
Chloromethane	0.007	ug	<	<	<
Bromomethane	0.005	"	0.13**	0.69**	0.014**
Vinyl Chloride	0.013	"	<	<	<
Chloroethane	0.007	"	<	<	<
Methylene Chloride	0.019	"	2.5*,**	0.43**	1.3*,**
Acetone	0.045	"	3.5*,**	2.8*,**	3.6*,**
Carbon Disulfide	0.018	"	<	<	<
1,1-Dichloroethene	0.007	"	0.020**	<	<
1,1-Dichloroethane	0.004	"	<	<	<
1,2-Dichloroethene(total)	0.007	"	<	<	<
Chloroform	0.008	"	<	<	<
1,2-Dichloroethane	0.006	"	<	<	<
2-Butanone	0.036	"	<	<	<
1,1,1-Trichloroethane	0.014	"	<	<	<
Carbon Tetrachloride	0.016	"	<	<	<
Bromodichloromethane	0.011	"	<	<	<
1,2-Dichloropropane	0.008	"	<	<	<
cis-1,3-Dichloropropene	0.007	"	<	<	<
Trichloroethene	0.009	"	<	<	<
Dibromochlormethane	0.008	"	<	<	<
1,1,2-Trichloroethane	0.016	"	<	<	<
Benzene	0.009	"	0.19	0.16	0.10
trans-1,3-Dichloropropene	0.007	"	<	<	<
Bromoform	0.012	"	<	<	<
4-Methyl-2-Pentanone	0.019	"	<	<	<
2-Hexanone	0.031	"	0.093	0.054	<
Tetrachloroethene	0.008	"	<	<	<
1,1,2,2-Tetrachloroethane	0.014	"	<	<	<
Toluene	0.009	"	0.062	0.036	0.039
Chlorobenzene	0.009	"	<	<	<
Ethylbenzene	0.006	"	0.006	<	<
Styrene	0.007	"	0.015	0.010	0.016
Xylene(total)	0.015	"	0.034	<	0.016
1,1,2-Trichlorotrifluoroethane	0.020	"	<	<	<
Surrogate Recoveries		%			
d4-1,2-Dichloroethane			135**	127**	104**
d8-Toluene			98	99	116
Bromofluorobenzene			93	61	101
Field Spike		%			
d10-Ethylbenzene			95	104	111

			RTS#2/R2/0030	RTS#2/R2/0030	RTS#2/R3/0030
	Client ID:		19a/b	18a/b	17a/b
	Lab No.:		043206 98	043207 98	043208 98
	Date Sampled:		98/08/26	98/08/26	98/08/26
Component	**MDL**	**Units**			
Chloromethane	0.007	ug	<	<	<
Bromomethane	0.005	"	0.022**	0.067**	0.22***
Vinyl Chloride	0.013	"	<	<	<
Chloroethane	0.007	"	<	<	<
Methylene Chloride	0.019	"	1.8*,**	1.6*,**	3.2*,***
Acetone	0.045	"	3.1*,**	3.0*,**	4.4*,***
Carbon Disulfide	0.018	"	<	<	<
1,1-Dichloroethene	0.007	"	<	<	0.25***
1,1-Dichloroethane	0.004	"	<	<	<
1,2-Dichloroethene(total)	0.007	"	<	<	<
Chloroform	0.008	"	<	<	<
1,2-Dichloroethane	0.006	"	<	<	<
2-Butanone	0.036	"	<	<	<
1,1,1-Trichloroethane	0.014	"	<	<	<
Carbon Tetrachloride	0.016	"	<	<	<
Bromodichloromethane	0.011	"	<	<	<
1,2-Dichloropropane	0.008	"	<	<	<
cis-1,3-Dichloropropene	0.007	"	<	<	<
Trichloroethene	0.009	"	<	<	<
Dibromochlormethane	0.008	"	<	<	<
1,1,2-Trichloroethane	0.016	"	<	<	<
Benzene	0.009	"	0.067	0.059	0.045
trans-1,3-Dichloropropene	0.007	"	<	<	<
Bromoform	0.012	"	<	<	<
4-Methyl-2-Pentanone	0.019	"	<	<	<
2-Hexanone	0.031	"	<	0.041	<
Tetrachloroethene	0.008	"	<	<	<
1,1,2,2-Tetrachloroethane	0.014	"	<	<	<
Toluene	0.009	"	0.037	0.027	0.022
Chlorobenzene	0.009	"	<	<	<
Ethylbenzene	0.006	"	<	<	<
Styrene	0.007	"	0.009	<	<
Xylene(total)	0.015	"	0.015	<	<
1,1,2-Trichlorotrifluoroethane	0.020	"	<	<	<
Surrogate Recoveries		%			
d4-1,2-Dichloroethane			144**	129**	142***
d8-Toluene			101	100	102
Bromofluorobenzene			67	79	107
Field Spike		%			
d10-Ethylbenzene			105	100	100

			RTS#2/R3/0030	RTS#2/R3/0030	RTS#2/R1CAT
	Client ID:		16a/b	1a/b	2a/b
	Lab No.:		043209 98	043210 98	043211 98
	Date Sampled:		98/08/26	98/08/26	98/08/26
Component	**MDL**	**Units**			
Chloromethane	0.007	ug	<	<	0.15
Bromomethane	0.005	"	0.008	0.014	0.074
Vinyl Chloride	0.013	"	<	<	<
Chloroethane	0.007	"	<	<	<
Methylene Chloride	0.019	"	3.7*	2.1*	2.7*
Acetone	0.045	"	1.9*	2.6	0.98
Carbon Disulfide	0.018	"	<	<	<
1,1-Dichloroethene	0.007	"	0.073	0.031	0.025
1,1-Dichloroethane	0.004	"	<	<	<
1,2-Dichloroethene(total)	0.007	"	<	<	<
Chloroform	0.008	"	<	<	<
1,2-Dichloroethane	0.006	"	<	<	<
2-Butanone	0.036	"	<	<	<
1,1,1-Trichloroethane	0.014	"	<	<	<
Carbon Tetrachloride	0.016	"	<	<	<
Bromodichloromethane	0.011	"	<	<	<
1,2-Dichloropropane	0.008	"	0.035	0.17	<
cis-1,3-Dichloropropene	0.007	"	<	<	<
Trichloroethene	0.009	"	<	<	<
Dibromochlormethane	0.008	"	<	<	<
1,1,2-Trichloroethane	0.016	"	<	<	<
Benzene	0.009	"	0.80	1.00	0.10
trans-1,3-Dichloropropene	0.007	"	<	<	<
Bromoform	0.012	"	<	<	<
4-Methyl-2-Pentanone	0.019	"	<	<	<
2-Hexanone	0.031	"	<	<	<
Tetrachloroethene	0.008	"	<	<	<
1,1,2,2-Tetrachloroethane	0.014	"	<	<	<
Toluene	0.009	"	0.081	0.052	0.17
Chlorobenzene	0.009	"	0.024	0.059	<
Ethylbenzene	0.006	"	0.007	0.009	0.009
Styrene	0.007	"	<	0.012	<
Xylene(total)	0.015	"	0.026	0.024	0.060
1,1,2-Trichlorotrifluoroethane	0.020	"	<	<	<
Surrogate Recoveries		%			
d4-1,2-Dichloroethane			153	139	101
d8-Toluene			98	93	102
Bromofluorobenzene			105	105	102
Field Spike		%			
d10-Ethylbenzene			94	97	98

			RTS#2/R1CAT	RTS#2/R1CAT
	Client ID:		3a/b	4a/b
	Lab No.:		043212 98	043213 98
	Date Sampled:		98/08/26	98/08/26
Component	**MDL**	**Units**		
Chloromethane	0.007	ug	0.14	7.6
Bromomethane	0.005	"	0.026	0.075
Vinyl Chloride	0.013	"	<	<
Chloroethane	0.007	"	<	<
Methylene Chloride	0.019	"	3.3*	2.4*
Acetone	0.045	"	1.1*	0.13
Carbon Disulfide	0.018	"	<	<
1,1-Dichloroethene	0.007	"	0.050	0.030
1,1-Dichloroethane	0.004	"	<	<
1,2-Dichloroethene(total)	0.007	"	<	<
Chloroform	0.008	"	<	<
1,2-Dichloroethane	0.006	"	<	<
2-Butanone	0.036	"	<	<
1,1,1-Trichloroethane	0.014	"	<	<
Carbon Tetrachloride	0.016	"	<	<
Bromodichloromethane	0.011	"	<	<
1,2-Dichloropropane	0.008	"	<	<
cis-1,3-Dichloropropene	0.007	"	<	<
Trichloroethene	0.009	"	0.014	<
Dibromochlormethane	0.008	"	<	<
1,1,2-Trichloroethane	0.016	"	<	<
Benzene	0.009	"	0.092	0.077
trans-1,3-Dichloropropene	0.007	"	<	<
Bromoform	0.012	"	<	<
4-Methyl-2-Pentanone	0.019	"	<	<
2-Hexanone	0.031	"	<	<
Tetrachloroethene	0.008	"	<	<
1,1,2,2-Tetrachloroethane	0.014	"	<	<
Toluene	0.009	"	0.15	0.12
Chlorobenzene	0.009	"	<	<
Ethylbenzene	0.006	"	0.012	0.007
Styrene	0.007	"	0.010	<
Xylene(total)	0.015	"	0.069	0.039
1,1,2-Trichlorotrifluoroethane	0.020	"	<	<
Surrogate Recoveries		%		
D4-1,2-Dichloroethane			108	103
D8-Toluene			99	101
Bromofluorobenzene			98	105
Field Spike		%		
D10-Ethylbenzene			95	101

Component	MDL	Units			
Batch Code:			0904EG01	0909EG01	0908EG01
Chloromethane	0.007	ug	<	<	<
Bromomethane	0.005	"	0.014	<	0.006
Vinyl Chloride	0.013	"	<	<	<
Chloroethane	0.007	"	<	<	<
Methylene Chloride	0.019	"	<	0.059	0.027
Acetone	0.045	"	0.072	<	<
Carbon Disulfide	0.018	"	<	<	<
1,1-Dichloroethene	0.007	"	<	<	<
1,1-Dichloroethane	0.004	"	<	<	<
1,2-Dichloroethene(total)	0.007	"	<	<	<
Chloroform	0.008	"	<	<	<
1,2-Dichloroethane	0.006	"	<	<	<
2-Butanone	0.036	"	<	<	<
1,1,1-Trichloroethane	0.014	"	<	<	<
Carbon Tetrachloride	0.016	"	<	<	<
Bromodichloromethane	0.011	"	<	<	<
1,2-Dichloropropane	0.008	"	<	<	<
cis-1,3-Dichloropropene	0.007	"	<	<	<
Trichloroethene	0.009	"	<	<	<
Dibromochlormethane	0.008	"	<	<	<
1,1,2-Trichloroethane	0.016	"	<	<	<
Benzene	0.009	"	0.012	0.013	0.012
trans-1,3-Dichloropropene	0.007	"	<	<	<
Bromoform	0.012	"	<	<	<
4-Methyl-2-Pentanone	0.019	"	<	<	<
2-Hexanone	0.031	"	<	<	<
Tetrachloroethene	0.008	"	<	<	<
1,2,2-Tetrachloroethane	0.014	"	<	<	<
Toluene	0.009	"	<	<	<
Chlorobenzene	0.009	"	<	<	<
Ethylbenzene	0.006	"	<	<	<
Styrene	0.007	"	<	<	<
Xylene(total)	0.015	"	<	<	<
1,1,2-Trichlorotrifluoroethane	0.020	"	<	<	<
Surrogate Recoveries		%			
d4-1,2-Dichloroethane			105	90	86
d8-Toluene			98	103	104
Bromofluorobenzene			107	107	110
Field Spike		%			
d10-Ethylbenzene			103	104	97

Analytical report

Job Name: LLNL
Sample Date: 8/18/98
Request by: R. Best
Analytical Method: Method 5 EPA
Date of Anaysis: 8/31/98 to 9/17/98
Source: ~~Baghouse~~ outlet

Analyst: Michael J. Wiley
Signature:

Lab ID Number	Sample (ml)	Aliquot (ml)	Parameter	Net Weight gain, (mg)	Result Blank Corrected
R1M5 (Probe/Nozzle rinse)	56.0ml	56.0ml	Particulate	0.71mg	0.11mg
R1M5 (Filter)	N/A	N/A	Particulate	-1.18mg	<0.05mg
R2M5 (Probe/Nozzle rinse)	69.0ml	69.0ml	Particulate	9.95mg	9.20mg
R2M5 (Filter)	N/A	N/A	Particulate	-0.76mg	<0.05mg
R3M5 (Probe/Nozzle rinse)	67.0ml	67.0ml	Particulate	1.70mg	0.98mg
R3M5 (Filter)	N/A	N/A	Particulate	0.52mg	0.52mg
R4M5 (Acetone blank)	50.0ml	50.0ml	Particulate	0.54mg	
R4M5 (Filter blank)	N/A	N/A	Particulate	0.00mg	

Comments: < 0.05 mg = Not detected

% Acetone Residue = 0.0014%

Calculations:

Probe/Nozzle rinse = Net weight - ((acetone blank wt./vol. acetone blank)*vol. acetone catch)

% Acetone residue = (New weight gain * 0.1) / (density of acetone * total sample volume)

Tolerance Limits: % Acetone residue = 0.001% wt.

Particulate weight = 1% of net wt., ±0.5 mg or ±0.05 mg depending upon precision

BEST ENVIRONMENTAL, INC. San Leandro, CA 94578 (510) 278-4011

Analytical report

Job Name: LLNL
Sample Date: 8/19/98
Request by: R. Best
Analytical Method: Method 5 EPA
Date of Anaysis: 8/31/98 to 9/17/98
Source: Catalyst outlet RTS #1

Analyst: Michael J. Wiley
Signature: Michael J. Wiley

Lab ID Number	Sample (ml)	Aliquot (ml)	Parameter	Net Weight gain, (mg)	Result Blank Corrected
R1M5 (Probe/Nozzle rinse)	32.0ml	32.0ml	Particulate	0.33mg	**0.50mg**
R1M5 (Filter)	N/A	N/A	Particulate	0.09mg	**0.09mg**
R4M5 (Acetone blank)	50.0ml	50.0ml	Particulate	-0.27mg	
R4M5 (Filter blank)	N/A	N/A	Particulate	0.00mg	

Comments: < 0.05 mg = Not detected

% Acetone Residue = -0.0007%

Calculations:

Probe/Nozzle rinse = Net weight - ((acetone blank wt./ vol. actone blank)*vol. acetone catch)

% Acetone residue = (New weight gain * 0.1) / (density of acetone * total sample volume)

Tolerance Limits: % Acetone residue = 0.001% wt.

Particulate weight = 1% of net wt., ±0.5 mg or ±0.05 mg depending upon precision

000107

BEST ENVIRONMENTAL, INC.

GRAVIMETRIC SAMPLE WORKSHEET

Project/Client: LLNL
Test Date(s): 8/18/98
Source: Outlet Baghouse
Analysis Date(s): 8/21/98 to

Probe/Nozzle Weights

Run #	Tin #	Sample Residue Wt. (mg)	Sample Vol. (ml) Vaw	Acetone Blank Wt. (mg) Ma	Acetone Blank Vol. (ml) Va	Acetone Blank Correction Wt. (mg) Wa	Net Wt. gain (mg)
R1 Baghouse outlet	271	56	0.71	50	0.54	0.60	0.11
R2	272	69	9.95	↓	0.54	0.75	9.20
R3	276	67	1.70	↓	0.54	0.75	0.95
Cutout	X						
	277	Soak	0.54				

Acetone Blank Correction Wt. Wa = Ma * Vaw / Va
Net Wt. gain (mg) = Sample Residue Weight - Blank Correction

Filter Weights

Run #	Filter #		Tare Wt. (mg)		Gross Wt. (mg)		Net Wt. gain (mg)
	box 881						-1.18
	box 882						-0.25
	box 9243						0.52

Back-Half (H_2O) Condensible Fraction

Run #	Container Type/#	Total Sample Volume (ml) Vt	Aliquot Volume (ml) Va	Aliquot Dry Wt. (mg) Mal	Calculated Total Sample Dry Wt. (mg) Ms	Blank Correction Wt. (mg) Mb	Net Wt. gain (mg)

Total Sample Dry Weight (Ms) = (Vt/Va) * Mal
Blank Correction Wt. (Mb) = Ms(blank) * (Vt/Vt blank)
Net Weight = Ms - Mb

Back-Half (Organic) Condensible Fraction

Run #	Container Type/#	Total Sample Volume (ml) Vt	Aliquot Volume (ml) Va	Aliquot Dry Wt. (mg) Mal	Calculated Total Sample Dry Wt. (mg) Ms	Blank Wt. (mg) Mb	Net Wt. gain (mg)

Total Sample Dry Weight (Ms) = (Vt/Va) * Mal
Blank Correction Wt. (Mb) = Ms(blank) * (Vt/Vt blank)
Net Weight = Ms - Mb

000103

55

g:\reports mw\97\wsheet

BEST ENVIRONMENTAL, INC.

GRAVIMETRIC SAMPLE RECORD

Project/Client LCNL
Test Date(s) 8/28 198

Source Baghouse outlet
Method

Project Sample ID	Lab Container Type/#	Tare Wt. (g) from Tare Sheet	Gross Wt. (g)	Date	Time	Net Wt. gain (mg)	Initial
R1MS-F1	~~Box~~		2.32124	9/1/98	13:07		
	~~831~~	Date	2.32122	9/4/98	16:59		
	Tin	(2.32051)					
	271	Wt.				0.7mg	
		(~~2.32051~~)	(2.32123)				
R2MS-F1H	Tin		2.32454	9/1/98	13:10		
	272	Date	2.32451	9/4/98	16:57		
		Wt.					
		(2.31456)	(2.32453)			997	
R3MS-F1H	Tin		2.31226	9/1/98	13:12		
	276	Date	2.31226	9/4/98	16:55		
		Wt.				1.70	
		(2.31056)	(2.31226)				
R4MS-F1H	Tin		2.35942	9/1/98	13:14		
	277	Date	2.35937	9/4/98	16:53		
		Wt.				0.54	
		(2.35886)	(2.35940)				
R1MS-Filter	box		0.38248	9/1/98	13:16		
	981	Date	0.38245	9/4/98	7:19		
		Wt.				-1.18	
		(0.38363)	(0.38246)				
R2MS-Filter	box		0.38556	9/1/98	13:18		
	882	Date	0.38512	9/4/98	17:16		
			0.38512	9/8/98			
		Wt.					
		(0.38588)	(0.38512)			-0.76	
R3MS-Filter	box		0.36148	9/1/98	13:20		
	9245	Date	0.36166	9/4/98	17:15		
			0.36116	9/8/98	11:19		
		Wt.	0.36162	9/8/98	17:22		
		(0.36077)	0.36105	9/9/98	8:40		
R4MS-Filter			0.36146	9/9/98	10:21		
		Date	0.36057	9/11/98	10:46		
			(0.36129)			(0.52)	
		Wt.					

TARE to 0.0001 ± 5Δ

Final Wt. - either ± 0.0005Δ or 0.005Δ or ± 4% Δ of Net Wt.

g/reports/mw/97/wtsheet

BEST ENVIRONMENTAL, INC.

GRAVIMETRIC SAMPLE RECORD

Project/Client LLNL Source ~~Blanks~~ Quartz

Test Date(s) 8/18/98 8/19 Method

Project Sample ID	Lab Container Type/#	Tare Wt. (g) from Tare Sheet	Gross Wt. (g)	Date	Time	Net Wt. gain (mg)	Initial
RIMS-BPH-	Tan		2.33524	9/23/98	12:47		
	245	Date					
		Wt.					
		2.33491				0.33	
RIMS - BPH Filter			0.11014	9/23/98	12:49		
	ink	Date					
	822						
		Wt.					
		0.11005				0.09	
RIMS-BPH							
		Date					
		Wt.					
RIMS-BPH							
		Date					
		Wt.					
		Date					
		Wt.					
		Date					
		Wt.					
		Date					
		Wt.					
		Date					
		Wt.					

TARE to 0.0001 ± 5Δ

Final Wt. - either ± 0.0005Δ or 0.005Δ or ± 4% Δ of Net Wt.

g/reports/mw/97/wtsheet

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 22, 1998

LAB No: SP 807981-1

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: RIMS/114-F/H-B-OUT
Sampled by :
Type of Sample: Solid

Sampled : August 18, 1998
Received : September 25, 1998
Completed : October 13, 1998
QA/QC ID# : 80798101- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/samp	0.1	± 1
Gross Beta	9310	pCi/samp	0.3	± 1
Tritium	H-1	pCi/samp	0.0	± 2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Plastic

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0182
FAX: 209/942-0423

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-8435
Mobile: 209/737-2399

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 22, 1998

LAB No: SP 807981-5

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: RIMS/114-FILTER-B-OUT
Sampled by :
Type of Sample: Air Filter

Sampled : August 18, 1998
Received : September 25, 1998
Completed : October 19, 1998
QA/QC ID# : 80798105- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/samp	0.00	± 0.38
Gross Beta	9310	pCi/samp	0.96	± 1.3
Tritium	H-1	pCi/samp	2.0	± 2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Glass

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

000112

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172

Office & Laboratory
3530 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0434
FAX: 209/942-0423

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-8435

57

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 21, 1998

LAB No: SP 807981-9

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: RIMS/114-IMP-B-OUT
Sampled by :
Type of Sample: Non Potable Water

Sampled : August 18, 1998
Received : September 25, 1998
Completed : October 20, 1998
QA/QC ID# : 80798109- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/L	20	± 4
Gross Beta	9310	pCi/L	1	± 7
Tritium	906.0	pCi/L	3000	±300

Results x 0.260 Ci
5.2
0.26
780

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Glass

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-9435
Mobile: 209/737-2093

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 22, 1998

LAB No: SP 807981-2

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: R2MS/114-F/H-B-OUT
Sampled by :
Type of Sample: Solid

Sampled : August 18, 1998
Received : September 25, 1998
Completed : October 13, 1998
QA/QC ID# : 80798102- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/samp	0.0	± 1
Gross Beta	9310	pCi/samp	0.6	± 1
Tritium	H-1	pCi/samp	31	± 2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Plastic

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

This report package is not intended for use in the State of Utah unless bound or paginated

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0182
FAX: 209/942-0423

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-8435
Modem: 209/737-0239

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 22, 1998

LAB No: SP 807981-6

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: R2MS/114-FILTER-B-OUT
Sampled by :
Type of Sample: Air Filter

Sampled : August 18, 1998
Received : September 25, 1998
Completed : October 19, 1998
QA/QC ID# : 80798106- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/samp	0.00	± 0.39
Gross Beta	9310	pCi/samp	0.62	± 1.3
Tritium	H-1	pCi/samp	1.0	± 2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Glass

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

000115

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-8435
Mobile: 209/737-2399

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 21, 1998

LAB No: SP 807981-10

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: R2MS/114-IMP-B-OUT
Sampled by :
Type of Sample: Non Potable Water

Sampled : August 18, 1998
Received : September 25, 1998
Completed : October 20, 1998
QA/QC ID# : 80798110- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/L	1	± 1
Gross Beta	9310	pCi/L	2	± 2
Tritium	906.0	pCi/L	2600	±300

Results x 0.742 1.60
0.24
0.48
629.2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Glass

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

This report package is not intended for use in the State of Utah unless bound or paginated

000116

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172

Office & Laboratory
2530 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0182
FAX: 209/942-0403

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-9435

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 22, 1998

LAB No: SP 807981-3

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: R3MS/114-F/H-B-OUT
Sampled by :
Type of Sample: Solid

Sampled : August 18, 1998
Received : September 25, 1998
Completed : October 13, 1998
QA/QC ID# : 80798103- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/samp	0.3	± 1
Gross Beta	9310	pCi/samp	0.5	± 1
Tritium	H-1	pCi/samp	0.0	± 2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Plastic

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

00117

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172
CA ELAP Certification No: 1573

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423
CA ELAP Certification No: 1563

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-8435
Mobile: 209/737-2399

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 22, 1998

LAB No: SP 807981-7

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: R3MS/114-FILTER-B-OUT
Sampled by :
Type of Sample: Air Filter

Sampled : August 18, 1998
Received : September 25, 1998
Completed : October 19, 1998
QA/QC ID# : 80798107- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/samp	0.12	± 0.43
Gross Beta	9310	pCi/samp	0.0	± 1.2
Tritium	H-1	pCi/samp	0.6	± 2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Glass

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

000115

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0919
FAX: 805/525-4172
CA ELAP Certification No. 1233

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423
CA ELAP Certification No. 1560

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-9435
Mobile: 209/737-0333

60

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 21, 1998

LAB No: SP 807981-11

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: R3MS/114-IMP-B-OUT
Sampled by :
Type of Sample: Non Potable Water

Sampled : August 18, 1998
Received : September 25, 1998
Completed : October 20, 1998
QA/QC ID# : 80798111- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/L	1	± 1
Gross Beta	9310	pCi/L	0.0	± 2
Tritium	906.0	pCi/L	2700	±300

Results X0.236 liter
0.24 ± 637.2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Glass

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

000119

Corporate Offices & Laboratory
PO Box 272 / 953 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172
CA ELAP Certification No: 1573

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0161
FAX: 209/942-0423
CA ELAP Certification No: 1553

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-8435
Mobile: 209/737-2399

BEST ENVIRONMENTAL, INC.

GRAVIMETRIC SAMPLE WORKSHEET

Project/Client: LLNC
Test Date(s): 8/26/98

Source: Bag out out
Analysis Date(s): 8/31/98 to

Probe/Nozzle Weights

Run #	Tin #	Sample Residue Wt. (mg)	Sample Vol. (ml) Vaw	Acetone Blank Wt. (mg) Ma	Acetone Blank Vol. (ml) Va	Acetone Blank Correction Wt. (mg) Wa	Net Wt. gain (mg)
	295	5C	0.04	-0.27	5C	-0.27	0.31
	296	↓	0.25	-0.27	↓	↓	0.52
	297	↓	3.21	-0.27	↓	↓	3.48
	294		-0.27				

Acetone Blank Correction Wt. Wa = Ma * Vaw / Va
Net Wt. gain (mg) = Sample Residue Weight - Blank Correction

Filter Weights

Run #	Filter #		Tare Wt. (mg)		Gross Wt. (mg)		Net Wt. gain (mg)
							0.11
							-0.08
							-0.04

Back-Half (H_2O) Condensible Fraction

Run #	Container Type/#	Total Sample Volume (ml) Vt	Aliquot Volume (ml) Va	Aliquot Dry Wt. (mg) Mai	Calculated Total Sample Dry Wt. (mg) Ms	Blank Correction Wt. (mg) Mb	Net Wt. gain (mg)

Total Sample Dry Weight (Ms) = (Vt/Va) * Mai
Blank Correction Wt. (Mb) = Ms(blank) * (Vt/Vt blank)
Net Weight = Ms - Mb

Back-Half (Organic) Condensible Fraction

Run #	Container Type/#	Total Sample Volume (ml) Vt	Aliquot Volume (ml) Va	Aliquot Dry Wt. (mg) Mai	Calculated Total Sample Dry Wt. (mg) Ms	Blank Wt. (mg) Mb	Net Wt. gain (mg)

Total Sample Dry Weight (Ms) = (Vt/Va) * Mai
Blank Correction Wt. (Mb) = Ms(blank) * (Vt/Vt blank)
Net Weight = Ms - Mb

000135

BEST ENVIRONMENTAL, INC.

GRAVIMETRIC SAMPLE RECORD

Project/Client LLNL Source Bayhouse out
Test Date(s) 9/26/98 Method

Project Sample ID	Lab Container Type/#	Tare Wt. (g) from Tare Sheet	Gross Wt. (g)	Date	Time	Net Wt. gain (mg)	Initial
R1M17-F1H	T.H		2.29998	9/1/98	11:48		
	295	Date	2.30002	9/4/98	17:02		
		Wt.					
		(2.29956)	(2.30000)			0.44	
R2M17-F1H	T.H		2.30513	9/1/98	11:50		
	296	Date	2.30517	9/4/98	17:04		
		Wt.					
		(2.30490)	(2.30515)			0.25	
R3M17-F1H	T.H		2.32647	9/1/98	11:52		
	297	Date	2.32644	9/4/98	17:06		
		Wt.					
		(2.32625)	(2.32646)			0.21	
R4M17-F1H	T.H		2.31240	9/1/98	11:56		
	299	Date	2.31245	9/4/98	17:08		
		Wt.					
		(2.31270)	(2.31243)			-0.27	
R1M17-F1Hv	Cnl		0.10952	9/1/98	11:59		
	829	Date	0.10947	9/4/98	17:22		
		Wt.					
		(0.10939)	(0.10950)			0.11	
R2M17-F1Hv	cnl		0.10181	9/1/98	12:01		
	839	Date	0.10180	9/4/98	17:20		
		Wt.				-0.08	
		(0.10189)	(0.10181)				
R3M17-F1Hv	Cnl		0.10206	9/1/98	12:04		
	833	Date	0.10209	9/4/98	17:18		
		Wt.					
		(0.10212)	(0.10207)			-0.04	
		Date					
		Wt.					

TARE to 0.0001 ± 5Δ

Final Wt. - either ± 0.0005Δ or 0.005Δ or = 4% Δ of Net Wt.

g/reports/mw/97/wtsheet

000129

BEST ENVIRONMENTAL, INC.

GRAVIMETRIC SAMPLE RECORD

Project/Client LLNL
Test Date(s) 8/26/98

Source rat outlet
Method M17

Project Sample ID	Lab Container Type/#	Tare Wt. (g) from Tare Sheet	Gross Wt. (g)	Date	Time	Net Wt. gain (mg)	Initial
RIM17 F/H	T.C.		2.33148	9/1/98	11:54		
	298	Date	2.33149	9/4/98	1209		
		Wt.					
		(2.33160)	(2.33149)			-0.11	
RIM17 - F/H	Cal	7/21/98	0.11095	9/1/98	11:57		
	828	Date	0.11093				
		Wt.				0.10	
		(0.11084)	(0.11094)				
		Date					
		Wt.					
		Date					
		Wt.					
		Date					
		Wt.					
		Date					
		Wt.					
		Date					
		Wt.					

TARE to 0.0001 = 5Δ

Final Wt. - either = 0.0005Δ or 0.005Δ or = 4% Δ of Net Wt.

g/reports/mw/97/wtsheet

000150

62

BEST ENVIRONMENTAL, INC. Ph (510) 278-4011 Fx (510) 278-4018

Project ID: LLNL
Analytical Lab: BET

SAMPLE CHAIN OF CUSTODY

#	DATE	TIME	SAMPLE ID Source/Run#/Method/Fraction	CONTAINER size / type	Volume	Storage Temp °F	SAMPLE DESCRIPTION	ANALYSIS	TAT
1	8/26/98		R1M17 - F1H - catcher	120d	8ml		catcher Run Active		
2			R4M17 - F1H						
3			R1M17 - Filter	Cal 828	--		catcher Run TM296		
4									
5									
6			R1M17 - Filter						
7			R2 " "	Cal 829			Baghouse outlet		
8			R3 " "	Cal 831					
9				Cal 832					
10									
11			R1-3 F1H1*	120d	30ml	68°F	T.4295		
12							T.4296		
13							TM 297		
14									
15			R4 F1H - Active blank	120d	8ml		TM 299		
16									
17									
18									
19									
20									
21									

SPECIAL INSTRUCTIONS: Record & Report all liquid sample volumes.

Split into 3 parts.

Submit Results to: Attn: @Best Environmental Inc, 15890 Foothill Blvd., San Leandro, CA 94578

Relinquished by: _____ Received by: _____ Date: 8/30/98 Time: _____

Relinquished by: _____ Received by: _____ Date: _____ Time: _____

Relinquished by: _____ Received by: _____ Date: _____ Time: _____

SAMPLE CONDITION AS RECEIVED: OK or not OK

h:\forms\field\coc

63

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 22, 1998

LAB No: SP 807981-16

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: RIMS/114-F/H-B-OUT
Sampled by :
Type of Sample: Solid

Sampled : August 26, 1998
Received : September 25, 1998
Completed : October 13, 1998
QA/QC ID# : 80798116- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/samp	0.0	± 1
Gross Beta	9310	pCi/samp	0.0	± 1
Tritium	H-1	pCi/samp	0.0	± 2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Glass

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

000132

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172
CA ELAP Certification No: 1573

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423
CA ELAP Certification No: 1563

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-8435
Mobile: 209/737-0389

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 22, 1998

LAB No: SP 807981-20

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: RIMS/114-FILTER-B-OUT
Sampled by :
Type of Sample: Air Filter

Sampled : August 26, 1998
Received : September 25, 1998
Completed : October 19, 1998
QA/QC ID# : 80798120- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/samp	0.00	± 0.37
Gross Beta	9310	pCi/samp	0.0	± 1.2
Tritium	H-1	pCi/samp	0.2	± 2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Glass

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

000133

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172
CA ELAP Certification No: 1570

Office & Laboratory
3500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423
CA ELAP Certification No: 1563

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-9435
Mobile: 209/737-2399

64

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 21, 1998

LAB No: SP 807981-24

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: R1MS/114-IMP-B-OUT
Sampled by :
Type of Sample: Non Potable Water

Sampled : August 26, 1998
Received : September 25, 1998
Completed : October 20, 1998
QA/QC ID# : 80798124- A

Analytical Results

Results x0.372 liter

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/L	0.0	± 1
Gross Beta	9310	pCi/L	0.0	± 2
Tritium	906.0	pCi/L	732000	±3300

199,104

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Glass

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

000134

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172
CA ELAP Certification No: 1573

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423
CA ELAP Certification No: 1563

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-8435
Mobile: 209/737-2399

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 22, 1998

LAB No: SP 807981-17

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: R2MS/114-F/H-B-OUT
Sampled by :
Type of Sample: Solid

Sampled : August 26, 1998
Received : September 25, 1998
Completed : October 13, 1998
QA/QC ID# : 80798117- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/samp	0.4	± 1
Gross Beta	9310	pCi/samp	0.1	± 1
Tritium	H-1	pCi/samp	0.0	± 2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Plastic

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172
CA ELAP Certification No: 1573

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423
CA ELAP Certification No: 1563

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-9435
Mobile: 209/737-2399

65

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 22, 1998

LAB No: SP 807981-21

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: R2MS/114-FILTER-B-OUT
Sampled by :
Type of Sample: Air Filter

Sampled : August 26, 1998
Received : September 25, 1998
Completed : October 19, 1998
QA/QC ID# : 80798121- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/samp	0.00	± 0.34
Gross Beta	9310	pCi/samp	0.0	± 1.1
Tritium	H-1	pCi/samp	2	± 2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Glass

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

000130

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172
CA ELAP Certification No: 1573

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423
CA ELAP Certification No: 1563

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-8435
Mobile: 209/737-2099

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 21, 1998

LAB No: SP 807981-25

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: R2MS/114-IMP-B-OUT
Sampled by :
Type of Sample: Non Potable Water

Sampled : August 26, 1998
Received : September 25, 1998
Completed : October 20, 1998
QA/QC ID# : 80798125- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/L	0.1	± 1
Gross Beta	9310	pCi/L	1	± 2
Tritium	906.0	pCi/L	702000	±3200

Results x 0.253 MDA

0.03
0.25
177,606

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Glass

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

000137

This report package is not intended for use in the State of Utah unless bound or paginated

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0919
FAX: 805/525-4172
CA ELAP Certification No: 1573

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423
CA ELAP Certification No: 1563

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-8435
Mobile: 209/737-2399

Lde

FGL ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 22, 1998

LAB No: SP 807981-18

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: R3MS/114-F/H-B-OUT
Sampled by :
Type of Sample: Solid

Sampled : August 26, 1998
Received : September 25, 1998
Completed : October 13, 1998
QA/QC ID# : 80798118- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/samp	0.4	± 1
Gross Beta	9310	pCi/samp	0.0	± 1
Tritium	H-1	pCi/samp	0.0	± 2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Plastic

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

000198

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172
CA ELAP Certification No: 1573

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423
CA ELAP Certification No: 1563

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-9435
Mobile: 209/737-2399

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 22, 1998

LAB No: SP 807981-22

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: R3MS/114-FILTER-B-OUT
Sampled by :
Type of Sample: Air Filter

Sampled : August 26, 1998
Received : September 25, 1998
Completed : October 19, 1998
QA/QC ID# : 80798122- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/samp	0.00	± 0.34
Gross Beta	9310	pCi/samp	0.0	± 1.2
Tritium	H-1	pCi/samp	2	± 2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Glass

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172
CA ELAP Certification No: 1573

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423
CA ELAP Certification No: 1586

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-9435
Mobile: 209/737-2399

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 21, 1998

LAB No: SP 807981-26

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: R3MS/114-IMP-B-OUT
Sampled by :
Type of Sample: Non Potable Water

Sampled : August 26, 1998
Received : September 25, 1998
Completed : October 20, 1998
QA/QC ID# : 80798126- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/L	7	± 1
Gross Beta	9310	pCi/L	0.6	± 2
Tritium	906.0	pCi/L	727000	±3300

Results X 0.260 liter
1.82
0.16
189,020

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Glass

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

This report package is not intended for use in the State of Utah unless bound or paginated

0001.01

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172
CA ELAP Certification No: 1573

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423
CA ELAP Certification No: 1563

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-8435
Mobile: 209/737-2399

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 22, 1998

LAB No: SP 807981-28

RE: Radiological Analysis

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

Sample Site: LLNL
Description: R1MS/114-F/H-CAT-OUT
Sampled by :
Type of Sample: Solid

Sampled : August 26, 1998
Received : September 25, 1998
Completed : October 13, 1998
QA/QC ID# : 80798128- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/samp	0.3	± 1
Gross Beta	9310	pCi/samp	0.0	± 1
Tritium	H-1	pCi/samp	0.0	± 2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Plastic

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

000141

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172
CA ELAP Certification No: 1573

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423
CA ELAP Certification No: 1563

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-8435
Mobile: 209/737-2399

68

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 22, 1998

LAB No: SP 807981-29

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: RIMS/114-Filter-CAT-OUT
Sampled by :
Type of Sample: Air Filter

Sampled : August 26, 1998
Received : September 25, 1998
Completed : October 19, 1998
QA/QC ID# : 80798129- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/samp	0.00	± 0.34
Gross Beta	9310	pCi/samp	0.0	± 1.1
Tritium	H-1	pCi/samp	1.2	± 2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Glass

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172
CA ELAP Certification No: 1573

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423
CA ELAP Certification No: 1563

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-9435
Mobile: 209/737-2399

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 21, 1998

LAB No: SP 807981-30

RE: Radiological Analysis

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

Sample Site: LLNL
Description: RIMS/114-IMP-CAT-OUT
Sampled by :
Type of Sample: Non Potable Water

Sampled : August 26, 1998
Received : September 25, 1998
Completed : October 20, 1998
QA/QC ID# : 80798130- A

Analytical Results

Results X

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/L	0.0	± 1
Gross Beta	9310	pCi/L	0.3	± 3
Tritium	906.0	pCi/L	46400	±900

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Glass

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172
CA ELAP Certification No: 1573

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423
CA ELAP Certification No: 1563

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-9435
Mobile: 209/737-3399

FGL ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 22, 1998

LAB No: SP 807981-19

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: R4MS/114-F/H-B-OUT-BLK
Sampled by :
Type of Sample: Solid

Sampled : August 26, 1998
Received : September 25, 1998
Completed : October 13, 1998
QA/QC ID# : 80798119- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/samp	0.1	± 1
Gross Beta	9310	pCi/samp	0.2	± 1
Tritium	H-1	pCi/samp	0.0	± 2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Plastic

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

000144

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172
CA ELAP Certification No: 1573

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423
CA ELAP Certification No: 1563

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-8435
Mobile: 209/737-2399

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 22, 1998

LAB No: SP 807981-23

RE: Radiological Analysis

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

Sample Site: LLNL
Description: R4MS/114-FILTER-B-OUT-BLK
Sampled by :
Type of Sample: Air Filter

Sampled : August 26, 1998
Received : September 25, 1998
Completed : October 19, 1998
QA/QC ID# : 80798123- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/samp	0.00	± 0.37
Gross Beta	9310	pCi/samp	0.0	± 1.2
Tritium	H-1	pCi/samp	1.6	± 2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Glass

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

00145

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172
CA ELAP Certification No: 1573

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423
CA ELAP Certification No: 1563

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-8435
Mobile: 209/737-2399

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 21, 1998

LAB No: SP 807981-27

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: R4MS/114-IMP-B-OUT
Sampled by :
Type of Sample: Non Potable Water

Sampled : August 26, 1998
Received : September 25, 1998
Completed : October 20, 1998
QA/QC ID# : 80798127- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/L	0.0	± 1
Gross Beta	9310	pCi/L	0.0	± 3
Tritium	906.0	pCi/L	1700	±300

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Glass

x0.200 Her = 340

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

000146

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172
CA ELAP Certification No: 1573

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423
CA ELAP Certification No: 1563

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-9435
Mobile: 209/737-2399

ENVIRONMENTAL

Analytical Chemists

October 21, 1998

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

Radiochemistry Quality Assurance Report for sample: 807981

Actual sample results are contained in the accompanying analytical report(s).

Constituent	BATCH ID	EPA Method	Units	BLANK QA/QC DLR	BLANK QA/QC Result	BLANK QA/QC NOTE	CALIBRAION QA/QC Type	CALIBRAION QA/QC Conc.	CALIBRAION QA/QC % REC	CALIBRAION QA/QC AR	CALIBRAION QA/QC NOTE	METHOD QA/QC Type	METHOD QA/QC Conc.	METHOD QA/QC % REC	METHOD QA/QC % REC	METHOD QA/QC AR	METHOD QA/QC % DIF	METHOD QA/QC MAV	METHOD QA/QC NOTE
Gross Alpha	0A 2B	900.0	pCi/cm2	0.03	ND		LCS	25.0	81.2	75-125		BS	25.0	100	95.2	75-125	4.9	25.0	
	0A 2C	900.0	pCi/L	1.0	0.3		LCS	7.12	123	75-125		BS	20.0	78.5	95.5	70-130	19.2	25.0	
Gross Beta	0A 2B	900.0	pCi/cm2	0.05	ND		LCS	86.0	98.5	75-125		BS	86.0	98.8	98.0	75-125	0.8	20.0	
	0A 2C	900.0	pCi/L	1.0	ND		LCS	106	82.4	75-125		BS	22.0	95.5	85.9	75-125	10.5	25.0	
Tritium	0A 2B	906.0	pCi/L	200	ND		LCS	367	98.9	75-125		BS	367	98.6	100	75-125	1.6	20.0	
	0A 2C	906.0	pCi/L	200	ND		LCS	367	100	75-125		BS	367	102	101	75-125	0.8	20.0	
Gross Alpha	0A 2A	900.0	pCi/L	1.0	0.5		LCS	35.6	83.7	75-125		MS	400	105	99.2	60-140	5.6	30.0	
Gross Beta	0A 2A	900.0	pCi/L	1.0	ND		LCS	535	103	75-125		MS	457	102	93.4	60-140	9.1	30.0	
Tritium	0A 2A1	906.0	pCi/L	200	ND		LCS	4000	107	75-125		BS	4000	97.5	100	75-125	2.5	20.0	

FGL ID = 19981006 ND => Not Detected at ar above DLR. DLR => Detection Limit for Reporting purposes. N/A => Not Applicable NOTE => See note indicated below.
An explanation of QA terms is provided on the reverse side of this page.

FGL ENVIRONMENTAL, INC.

Kurt Wilkinson, B.S., QA Director

MMF:vl

Corporate Offices & Laboratory
P.O. Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: (805) 659-0910

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: (209) 942-0181

Field Office
Visalia, California
TEL: (209) 734-9473
Mobile: (209) 737-2399

~~85981~~ 85981 2-17651

BEST ENVIRONMENTAL, INC. Ph (510) 278-4011; Fx (510) 278-4018

15890 Foothill Blvd San Leandro, Ca 94578-2101 (510) 278-4011, (510) 278-4018 FAX

Project ID: LLNL

SAMPLE CHAIN OF CUSTODY

Analytical Lab: ~~PACE Inc. Analytical Services~~ FGL

#	DATE	TIME	SAMPLE ID Source/Run#/Method/Fraction	CONTAINER size / type	Volume	Storage Temp °F	SAMPLE DESCRIPTION	ANALYSIS	TAT
1	8/18/98	S	R1MS/114-F/H-B-out	Aluminum tray	271	68°	Acetone rinse Probe&Nozzle		
2	8/18/98	S	R2MS/114-F/H-B-out	Aluminum tray	272		Acetone rinse Probe&Nozzle		
3	" "	S	R3MS/114-F/H-B-out	" "	276		" "		
4	" "	S	R4MS/114-F/H-B-out-BLK	" "	277		Acetone blank		
5									
6	8/18/98	AF	R1MS/114-Filter B-out	8 OZ Glass			Glass fiber filter		
7	" "	AF	R2MS/114-Filter B-out	" "			" "		
8	" "	AF	R3MS/114-Filter B-out	" "			" "		
9	" "	AF	R4MS/114-Filter B-out BLK	" "			Glass fiber filter blank		
10									
11	8/18/98	WW	R1MS/114-IMP-B-out	Sound Glass			Impinger DI water rinse		
12	" "	WW	R2MS/114-IMP-B-out	" "			" "		
13	" "	WW	R3MS/114-IMP-B-out	" "			" "		
14	" "	WW	R4MS/114-IMP-B-out BLK	" "			DI water blank		
15									
16	8/19/98	S	R1MS/114-F/H-catout				Acetone Probe/Nozzle rinse		
17	8/19/98	AF	R1MS/114-Filter-catout				Glass Fiber Filter		
18	8/19/98	WW	R1MS/114-IMP-catout				DI water Impinger + rinse		
19									
20									
21									

SPECIAL INSTRUCTIONS: Record & Report all liquid sample volumes.

Analysis using method 9310 (EPA) & 906.0 (EPA)
Alpha Beta (ww) or other — TRITIUM SLD+H2O

** Send R1-4MS/114-IMP-B-out & R1MS/114 IMP-cat out after completion of analysis.

Submit Results to: Attn: [illegible] Best Environmental Inc. 15890 Foothill Blvd., San Leandro, CA 94578

Relinquished by: [signature] Received by: UPS ENTRY 3 GROUND TRACKING NUMBER 1Z 8E6 879 03 1000 898 2 Date: 9/23/98 Time:

Relinquished by: UPS Received by: [signature] Date: 9-25-98 Time:

Relinquished by: Received by: Date: Time:

SAMPLE CONDITION AS RECEIVED: OK or not OK

h:\forms\field\coc

OCT 21 1998

BEST ENVIRONMENTAL, INC. Ph (510) 278-1011; Fx (510) 278-1018

Project ID: LLNL

Analytical Lab: ~~Kiff Analytical - Seattle~~ FGL

SAMPLE CHAIN OF CUSTODY

#	DATE	TIME	SAMPLE ID Source/Run#/Method/Fraction	CONTAINER size / type	Volume	Storage Temp °F	SAMPLE DESCRIPTION	ANALYSIS	TAT
1	8/26/98	S	R1MS/114 - F/H - B-out	Aluminum tray	TM 295		Acetone rinse Probe Nozzle		
2	8/26/98	S	R2MS/114 - F/H - B-out	" "	TM 296		Acetone rinse Probe Nozzle		
3	" "	S	R3MS/114 - F/H - B-out	" "	TM 297		" "		
4	" "	S	R4MS/114 - F/H - B-out-BLK	" "	TM 299		Acetone blanks		
5									
6	8/26/98	AF	R1MS/114 - Filter - B-out	80z Glass			Glass fiber filter		
7	" "	AF	R2MS/114 - Filter - B-out	" "			" "		
8	" "	AF	R3MS/114 - Filter - B-out	" "			" "		
9	" "	AF	R4MS/114 - Filter - B-out - BLK	" "			Glass fiber filter blank		
10									
11	8/26/98	WW	R1MS/114 - IMP - B-out	500ml Glass			Imp. DI water rinse		
12	" "	WW	R2MS/114 - IMP - B-out	" "			" "		
13	" "	WW	R3MS/114 - IMP - B-out	" "			" "		
14	" "	WW	R4MS/114 - IMP - B-out - BLK	" "			DI water blank		
15									
16									
17		9	R1MS/114 - F/H - cat out	Aluminum tray	TM 298		Acetone Probe / Nozzle		
18	8-26	AF	R1MS/114 - Filter - cat out	80z glass			Glass fiber filter		
19	8-26	WW	R1MS/114 - Imp - cat out	250ml Glass			DI water Imp. rinse		
20									
21									

SPECIAL INSTRUCTIONS: Record & Report all liquid sample volumes.

Analysis using Method 9310 (EPA) & 906.0 EPA

*Send R1-4MS/114-IMP-B-out & R1MS/114-IMP-cat out after completion of analysis.

Submit Results to: Attn: K. Bass

Best Environmental Inc. 15890 Foothill Blvd., San Leandro, CA 94578

Relinquished by: _____ Received by: _____ Date: 9/23/98 Time: _____

Relinquished by: UPS Received by: _____ Date: 9/25/98 Time: _____

Relinquished by: _____ Received by: _____ Date: _____ Time: _____

SAMPLE CONDITION AS RECEIVED: OK or not OK

h:\forms\field\coc

PHILIP SERVICES

HCL
0051

INORGANIC DATA PACKAGE
FOR
BEST ENVIRONMENTAL INC.
Project: Livermore

Philip Analytical Services Corporation
5555 North Service Road
Burlington, Ontario L7L 5H7

Submission #8I0098

Prepared by: Ancy Sebastian - CSR Initial : _____
Approved by: Dr. Ron McLeod - Principal Scientist Initial : _____

PROJECT NARRATIVE

PHILIP Analytical Services (Burlington ON)
Philip Project: AN980845
Philip Submission #:8I0098

Client: Best Environmental Inc.
Client Project: Livermore

I. SAMPLE RECEIPT/ANALYSIS

a) Sample Listing

Philip ID	Client Sample ID	Date Sampled	Date Received	Date Prepped	Run Date
Hydrogen Chloride via SW846 Method 26A					
043167 98	Method Blank	98/08/19	98/08/28	98/09/11	98/09/11
043168 98	R4M0051-HCl	98/08/19	98/08/28	98/09/11	98/09/11
043169 98	R1M0051-HCl	98/08/19	98/08/28	98/09/11	98/09/11
043170 98	R2M0051-HCl	98/08/19	98/08/28	98/09/11	98/09/11
043171 98	R3M0051-HCl	98/08/19	98/08/28	98/09/11	98/09/11
043172 98	R4M0051-H2SO4	98/08/26	98/08/28	98/09/11	98/09/11
043173 98	R1M0051-H2SO4	98/08/26	98/08/28	98/09/11	98/09/11
043174 98	R2M0051-H2SO4	98/08/26	98/08/28	98/09/11	98/09/11
043175 98	R3M0051-H2SO4	98/08/26	98/08/28	98/09/11	98/09/11
043176 98	R1CatOut-HCl/Cl2	98/08/26	98/08/28	98/09/11	98/09/11

Run Date is defined as the date of injection of the last calibration standard (12 hour or less) prior to the samples analyzed within that run sequence. Therefore the time of calibration injection that defines the run date is always within 12 hours of the time of sample injection.

b) Shipping Problems: none encountered

c) Documentation Problems: none encountered

II. SAMPLE PREP:

No problems encountered

III. SAMPLE ANALYSIS:

See also comments within the appropriate Certificate of Analysis.

a) Hold Times: all within recommended hold times

b) Instrument Calibration: all within control limits

I certify that this data package is in compliance with the terms and conditions of the contract, both technically and for completeness, for other than the conditions detailed above. In addition, I certify, that to the best of my knowledge and belief, the data as reported are true and accurate. Release of the data contained in this data package has been authorized by the cognizant laboratory official or his/her designee, as verified by this signature.

R A McLeod

Ronald A. McLeod, Principal Sci., Ph.D, C.Chem

98 10 23

Date

PHILIP SERVICES

Certificate of Analysis

CLIENT INFORMATION		LABORATORY INFORMATION	
Attention:	Dan Cartner	**Contact:**	Ron McLeod
Client Name:	Best Environmental Inc.	**Project:**	AN980845
Project:	Livermore	**Date Received:**	98/08/28
Project Desc:	Stack Emissions	**Date Reported:**	98/09/15
Address:	15890 Foothill Blvd San Leandro,CA CA 94578	**Submission No.:**	8I0098
		Sample No.:	043167-043176
Fax Number:	510 278 4018		
Phone Number:	510 278 4011		

NOTES: *'-' = not analysed '<' = less than Method Detection Limit (MDL) 'NA' = no data available*
LOQ can by determined for all analytes by multiplying the appropriate MDL X 3.33
Solids data is based on dry weight except for biota analyses.
Organic analyses are not corrected for extraction recovery standards except for isotope dilution methods. (i.e. CARB 429 PAH. all PCDD/F and DBD/DBF analyses)

Methods used by PASC are based upon those found in 'Standard Methods for the Examination of Water and Wastewater', Nineteenth Edition. Other methods are based on the principles of MISA or EPA methodologies. New York State: ELAP Identification Number 10756.

All work recorded herein has been done in accordance with normal professional standards using accepted testing methodologies, quality assurance and quality control procedures except where otherwise agreed to by the client and testing company in writing. Any and all use of these test results shall be limited to the actual cost of the pertinent analysis done. There is no other warranty expressed or implied. Your samples will be retained at PASC for a period of three weeks from receipt of data or as per contract.

COMMENTS:

Certified by:

PASC - Certificate of Analysis

Client ID:		Method Blank	Blank Spike #1	Blank Spike #1	Blank Spike #2	Blank Spike #2	R4M0051 HCl	R4M0051 HCl	R1M0051 HCl	R1M0051 HCl
Lab No.:		043167 98	043167 98	043167 98	043167 98	043167 98	043168 98	043168 98	043169 98	043169 98
Date Sampled:		98/08/19	98/08/19	98/08/19	98/08/19	98/08/19	98/08/19	98/08/19	98/08/19	98/08/19
Component	MDL Units			% Recoveries		% Recoveries		Duplicate		Duplicate
Impinger volume measured	ml	100	-	-	-	-	21	-	46	-
Hydrogen Chloride	0.008 mg	<	0.37	90	0.37	90	<	<	<	<

00006

	Client ID:		R1M0051 HCl	R1M0051 HCl	R1M0051 HCl	R1M0051 HCl	R2M0051 HCl	R2M0051 HCl	R3M0051 HCl	R3M0051 HCl	R4M0051 H2SO4	R4M0051 H2SO4
	Lab No.:		043169 98	043169 98	043169 98	043169 98	043170 98	043170 98	043171 98	043171 98	043172 98	043172 98
	Date Sampled:		98/08/19	98/08/19	98/08/19	98/08/19	98/08/19	98/08/19	98/08/19	98/08/19	98/08/26	98/08/26
Component	MDL	Units	M. Spike	MS % Rec.	MS Dup	MSD % Rec.		Duplicate		Duplicate		Duplicate
Impinger volume measured		ml	-	-	-	-	48	-	48	-	13	-
Hydrogen Chloride	0.008	mg	0.87	91	0.86	91	<	<	<	<	<	<

00007

Client ID:			R1M0051 H2SO4	R1M0051 H2SO4	R2M0051 H2SO4	R2M0051 H2SO4	R3M0051 H2SO4	R3M0051 H2SO4	R1CatOut HCl/Cl2	R1CatOut HCl/Cl2
Lab No.:			043173 98	043173 98	043174 98	043174 98	043175 98	043175 98	043176 98	043176 98
Date Sampled:			98/08/26	98/08/26	98/08/26	98/08/26	98/08/26	98/08/26	98/08/26	98/08/26
Component	MDL	Units		Duplicate		Duplicate		Duplicate		Duplicate
Impinger volume measured		ml	40	-	34	-	30	-	30	-
Hydrogen Chloride	0.008	mg	<	<	<	<	<	<	<	<

APPENDIX C
FIELD DATA SHEETS

BEST ENVIRONMENTAL, INC. San Leandro, CA (510)278-4011

X9÷5+32

Isokinetic Sampling Data Sheet (Method 429)

Facility: LLNL **Date:** 8/18/98 **Run #:** 1 **Personnel:** B.R., MW, JM, RB, DC

Facility Information		Equipment Information		Sampling Information	
Location: FILTER INLET RTS #1		Meter #: 2654	Pitot #: —	Pbar: 30.0	
Port Dia.:	Depth:	Yd: 1.0089	Cp: —	Pstatic: -1.15	
Fitting:	Length:	ΔH@: 1.869	Noz. #: 5E	% O_2:	
Stack Dia: 1.375	Area: 0.010	Filter Box #: 4	D_n: .309	% CO_2:	
Upstream from disturbance: 2		Filter #: —	Mag. #: —	% H_2O:	
Downstream from disturbance: 8		Probe #: 2'	Umb. #: —	Run Mins: 180	
		Pyrometer #:			

Initial LC: .002 CFM @ 25 "Hg Final LC: .004 CFM @ 12 "Hg Pitot LC: ✓

Point	Time	Gas Meter Vol. Ft³	Meter Temp, °F In	Meter Temp, °F Out	Stack Temp, °F	ΔP	ΔH	Meter ACFM	SQRT ΔP	Temp, °F Probe	Temp, °F Filter	Temp, °F Imp.	Vac., "Hg	Notes
		528.206												
1	10:16	528.206	76	78	286	.19	1.904	.794	.436			42	8	
2	10:26	535.3	81	78	286	.19	1.648	.705	.436					
3	10:36	541.8	88	80	284.4	.19	1.662	.711	.436					
4	10:46	547.2	89	80	286.2	.19	1.663	.712	.436					
5	10:56	552.5	90	80	290.3	.24	2.091	.798	.490					
6	11:06	559.0	88	80	292.1	.20	1.735	.727	.447					
7	11:16	562.7	84	80	290.0	.20	1.733	.725	.447					Down 2½ min.
8	11:26	567.8	92	82	294.4	.18	1.565	.692	.424					
9	11:36	573.1	96	82	292.1	.18	1.576	.696	.424					
10	11:46	578.5	98	84	293.2	.18	1.579	.698	.424					
12:02 11	11:56	583.5	98	84	294.4	.18	1.577	.697	.424					
12:12 12	12:06	588.2	97	86	293.7	.18	1.58	.698	.424					
12:22 13	12:16	594.7	92	84	295.7	.20	1.739	.730	.447					
12:32 14	12:26	601.1	88	84	298.0	.20	1.728	.727	.447					
12:42 15	12:36	607.5	88	84	295.5	.20	1.733	.728	.444					
12:52 16	12:46	613.6	86	82	298.0	.20	1.721	.724	.447					
13:02 17	12:56	619.6	88	84	297.3	.20	1.729	.727	.447					
13:12 Down 1 minute 18	13:06	625.9	88	82	298.4	.20	1.724	.725	.447					
13:26 19	13:16	634.484												
20														
21														
22														
23														
24														
		106.278	85.58		292.54		1.705		.441					

Moisture Data	Initial	Final	Net	Rinse
Impinger #1	~~100~~			
Impinger #2	100	186	86	
Impinger(s) #				
Impinger(s) #				
Silica Gel:	200	239	39	
Total Net / Rinse:			119	
Total Sample Volume:				

Field Calculations	
Sample Vol., dscf:	
% H_2O:	
MWs:	
MWd:	
Stack Vel, ft/s:	
Flow rate, acfm:	
Flow rate, dscfm:	
% Isokinetics:	

Comments:

000159

G:\forms\field\iso.xls

Isokinetic Sampling Data Sheet (Method 429)

Facility: LLNL **Date:** 8-18-98 **Run #:** 2 **Personnel:** D.R., DC, J-, RB, 4

Facility Information		Equipment Information		Sampling Information	
Location: Filter Inlet PSP1		Meter #: 2151	Pitot #: —	Pbar: 30.0	
Port Dia.:	Depth:	Yd: 1.0089	Cp: —	Pstatic: -11.5	
Fitting:	Length:	ΔH@: 1.869	Noz. #: SE	% O_2:	
Stack Dia: 1.37	Area:	Filter Box #: 4	D_n: .309	% CO_2:	
Upstream from disturbance: 2		Filter #: —	Mag. #: —	% H_2O:	
Downstream from disturbance: 8		Probe #: 2'	Umb. #: —	Run Mins: 180	
		Pyrometer #: —			

Initial LC: .002 CFM@ 25 "Hg Final LC: .002 CFM@ 15 "Hg Pitot LC:

Point	Time	Gas Meter Vol. Ft³	Meter Temp. °F In	Meter Temp. °F Out	Stack Temp. °F	ΔP	ΔH	Meter ACFM	SQRT ΔP	Temp. °F Probe	Temp. °F Filter	Temp. °F Imp.	Vac. "Hg	Notes
		639.000												
14:13 1	~~14:17~~	649.3	88	82	297.1	.20	1.588	.668	.447			42	7	
1423 2	~~14:27~~	655.7	98	84	310.5	.20	1.715	.727	.447					
3	14:33	662.8	98	84	333.3	.20	1.666	.717	.447					
4	14:43	668.5	94	84	344.3	.20	1.637	.709	.447					
5	14:54	675.7	92	82	350.1	.20	1.619	.704	.447					
6	15:04	681.8	88	84	353.7	.20	1.609	.701	.447					
7	15:14	687.5	86	82	356.5	.20	1.598	.698	.447					
down 2 min. 8	15:24	683.0	86	82	358.5	.20	1.594	.697	.447					
9	15:36	700.2	100	84	360.1	.20	1.614	.706	.447					
10	15:46	708.1	100	86	361.0	.18	1.454	.671	.424					
11	15:56	714.2	100	88	359.8	.18	1.459	.673	.424					
12	16:06	722.1	98	88	360.0	.18	1.458	.673	.424					
13	16:16	729.3	92	88	360.0	.18	1.448	.668	.424					
14	16:26	736.1	92	86	360.0	.18	1.445	.667	.424					
15	16:36	741.8	90	86	362.3	.23	1.838	.751	.480					
down 1 min. 16	16:46	747.2	88	84	363.2	.23	1.829	.747	.480					
17	16:57	753.1	90	84	362.5	.23	1.834	.749	.490					
18	17:07	758.167	90	84	364.6	.23	1.830	.748	.480					
		119.167	88.67		350.97		1.624		.448					

Moisture Data	Initial	Final	Net	Rinse
Impinger #1	~~100~~			
Impinger #2	100	193	93	
Impinger(s) #				
Impinger(s) #				
Silica Gel:	206	239	33	
Total Net / Rinse:			126	
Total Sample Volume:				

Field Calculations	
Sample Vol., dscf:	
% H_2O:	
MWs:	
MWd:	
Stack Vel. ft/s:	
Flow rate, acfm:	
Flow rate, dscfm:	
% Isokinetics:	

Comments:

0001.0

G:\forms\fleet\dsa.xls

Isokinetic Sampling Data Sheet (Method 4 2 9)

Facility: LAWRENCE **Date:** 8-19-98 **Run #:** #3 **Personnel:** JM-DC-RB-MW

Facility Information		Equipment Information		Sampling Information	
Location: BAGHOUSE INLET #1/5		Meter #: 2.5EM2	Pitot #: MINI STD	Pbar: 29.9	
Port Dia.:	Depth:	Yd: 1.0089	Cp: .99	Pstatic: -4.0	
Fitting:	Length:	ΔH@: 1.869	Noz. #: 5E	% O_2: 14	
Stack Dia: 1.375	Area: 0.01	Filter Box #: —	D_n: .309	% CO_2: 8	
Upstream from disturbance:		Filter #: 1,2,3	Mag. #: —	% H_2O: 2.0	
Downstream from disturbance:		Probe #: 2'	Umb. #: —	Run Mins: 180 M	
		Pyrometer #: —			

Initial LC: .015 CFM@ 17 "Hg Final LC: .010 CFM@ 20 "Hg Pitot LC: ✓

Point	Time	Gas Meter Vol. Ft³	Meter Temp. °F In	Meter Temp. °F Out	Stack Temp. °F	ΔP	ΔH	Meter ACFM	SQRT ΔP	Temp. °F Probe	Temp. °F Filter	Temp. °F Imp.	Vac. "Hg	Notes
1	9:18	759.612	75	75	300	.185	1.757	.719	.430	221	177		10	
2	9:25:30		82	75	307	.175	1.658	.701	.418	219	182		10	
3	9:33	769.1	90	78	311	.175	1.666	.706	.418	220	182		13	
4	9:40:30	774.4	90	78	318	.175	1.651	.703	.418	222	182		15	
5	9:48	779.2	90	78	318	.175	1.651	.703	.418	223	182		16	
6	9:55:30	783.8	88	80	321	.175	1.645	.701	.418	223	182		20	
7	10:03	788.142			~~327~~	~~.22~~								
8	10:19	788.142	80	80	327	.22	2.037	.777	.469	219	179		9	
9	10:26:30	793.6	90	80	329	.22	2.050	.783	.469	224	182		11	
10	10:34	798.6	96	80	330	.22	2.059	.787	.469	226	182			
11	10:41:30	803.5	94	82	331	.22	2.056	.786	.469	229	182		14	
12	10:49	808 5	92	81	332	.22	2.043	.784	.469	229	182		17	
13	10:56:30	813.3	90	81	333	.22	2.042	.782	.469	228	182		19	
14	11:04	817.492												
15	11:15	817.492	82	82	334	.22	2.021	.775	.469	213	189		9	
16	11:22:30	822.8	92	82	338	.22	2.035	.782	.469	229	182		11	
17	11:30	828.0	96	82	339	.22	2.040	.784	.469	236	182		14	
18	11:37:30	833.0	94	82	341	.22	2.031	.782	.469	239	182		16	
19	11:45	837.8	92	83	342	.22	2.026	.780	.469	238	182		19	
20	11:52:30	842.5	88	83	344	.22	2.014	.777	.469	239	183		20	
21	12:00	846.767	~~85~~	~~83~~										
22	12:20	~~85~~	81	81	344	.22	1.997	.770	.469	221	175		7	
23	12:27:30	852.0	92	81	344	.22	2.013	.778	.469	237	189		12	
24	12:35	857.2	96	82	345	.22	2.024	.781	.469				13	
~~STOP~~	12:42:30	861.8	95	82	347	.22	2.018	.779	.469	240	183		14	
	12:50	866.2	94	82	347	.22	2.016	.779	.469	239	182		15	
*	13:00:30	870.2	89	83	348	.22	2.006	.775	.469	223	182		16	
	13:08	874.510												
		114.898	91.4		317.9		1856		.437					

45m

45m

3-MIN TURN-OFF & BLOW BACK

Moisture Data	Initial	Final	Net	Rinse
Impinger #1	~~150~~	~~192~~		
Impinger #2	100	180	80	
Impinger(s) #				
Impinger(s) #				
Silica Gel:	201	233.5	32.5	
Total Net / Rinse:			112.5	
Total Sample Volume:				

Field Calculations	
Sample Vol., dscf:	114.263
% H_2O:	4.4
MWs:	29.31
MWd:	
Stack Vel, ft/s:	34.99
Flow rate, acfm:	21.65
Flow rate, dsfcm:	14.0
% Isokinetics:	99.9

Comments: 10:03 STOPPED TRAIN FOR FILTER CHANGE Leak ✓ OK

000181

G:\forms\field\iso.xls

BEST ENVIRONMENTAL, INC.

Isokinetic Sampling Data Sheet (Method M5)

Facility: LLNL **Date:** 8/18/98 **Run #:** 1 **Personnel:** DC

Facility Information		Equipment Information		Sampling Information	
Location:	Cat. Out RTS #1	Meter #:	LS1-1	Pitot #:	—
Port Dia.:	6"	Yd:	1.0039	Cp:	.99
Depth:	—	ΔH@:	2.196	Noz. #:	~~6~~
Fitting:	—	Filter Box #:	4	D_n:	~~.500~~
Length:	—	Filter #:	—	Mag. #:	—
Stack Dia:	4.0	Probe #:	3	Umb. #	—
Area:	.08	Pyrometer #:		Pbar:	24.8
Upstream from disturbance:				Pstatic:	-2.5
Downstream from disturbance:				% O_2:	20
				% CO_2:	
				% H_2O:	
				Run Mins	

Initial LC: .004 CFM @ 25 "Hg Final LC: .006 CFM @ 15 "Hg Pitot LC: —

Point	Time	Gas Meter Vol. Ft³	Meter Temp. °F In	Meter Temp. °F Out	Stack Temp. °F	ΔP	ΔH	Meter ACFM	SQRT ΔP	Temp. °F Probe	Temp. °F Filter	Temp. °F Imp.	Vac. "Hg	Notes
	1428	106.053	80	75			3.0						14	
	1438	114.9	95	78									14	
	1448	123.9	104	84									14	
	1458	132.8	110	90									14	
	1508	141.8	111	91									14	
	1518	150.8	114	94									14	
	1528	159.9	116	96									14	~~15.0~~
	1538	168.8	118	97									14	13.7 SCFM
	1548	177.8	120	100									14	
	1558	186.9	120	100									14	
	1608	197.0	120	100									14	
	1618		120	100									14	
	1628	26	120	100									14	
	1638		120	100										
	48		120	100										
	58		120	100										
	08		120	100										
	18		120	100										
	1726	266.488												
		110.435	1044											

Moisture Data

	Initial	Final	Net	Rinse
Impinger #1	100		142	
Impinger #2	~~100~~		~~100~~	
Impinger(s) #				
Impinger(s) #				
Silica Gel:	200	238	38	
Total Net / Rinse:			180	
Total Sample Volume:				

Field Calculations

Sample Vol., dscf:
% H_2O:
MWs:
MWd:
Stack Vel, ft/s:
Flow rate, acfm:
Flow rate, dscfm:
% Isokinetics:

Comments:

BEST ENVIRONMENTAL, INC. RJC

CARB Method 5 / 501 / Cyclonic

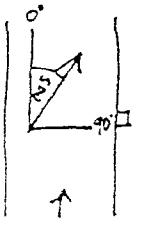
Facility: LLNL Date: 8-26-98 Method: ~~5~~ 23 Run #: 1

Facility Information		Equipment		Sampling Data	
Location: GSS Inlet RT 2		Meter #: 2	Pitot #: STD	PBar: 29.9	P Static: -10.0
Port Dia.	Depth:	Meter Yd: 1.0089	Pitot Cp: .99	%O_2 Ass.	%O_2 Actual:
Fitting Type:	Length:	ΔH@: 1.869	Noz. #: Q50	%CO_2 Ass.	%CO_2 Actual:
Stack Dia. 1.375	Area:	Filter #:	Noz. Dia. .376	%H_2O Ass.	Pitot LC:
Upstream Dist. 2		Probe #:		Test Mins. 180	Personnel: PR, DC, JM, RB
Downstream Dist. 8		Initial LC: .001 CFM @ 20 "Hg		Final LC: .001 CFM @ 20 "Hg	

Point	Clock Time	Gas Meter Vol. Ft^3	Meter °F Inlet	Meter °F Outlet	Stack Temp°F	Cyclonic Angle	Cos	ΔP	Avg ΔP @ pts.	ΔH setting	Meter CFM	SQRT ΔP	Imp °F	Vac. "Hg	Dwell Mins.
		~~874.~~													
		874.850											42		
1	9:03	883.3	77	74	298.2			.16		1.410	.650	.400		20	
2	9:13	889.9	78	74	309.9			.17		1.494	.669	.412			
3	9:23	896.4	80	76	305.9			.17		1.490	.670	.412			
4	9:33	902.4	80	76	309.7			.17		1.482	.668	.412			
5	10:06	910.7	88	78	316.6			.24		3.122	.970	.490			
6	10:16	919.4	94	78	318.4			.25		3.263	.994	.500			
7	10:26	929.1	90	80	321.4			.22		2.855	.930	.469			
8	10:36	938.5	90	80	320.9			.22		2.857	.930	.469			
9	10:46	948.4	90	80	322.3			.22		2.852	.929	.469			
10	10:56	958.1	90	80	323.8			.21		2.717	.907	.458			
11	11:06	967.7	92	81	325.0			.22		2.850	.930	.469			
12	11:16	977.5	92	82	326.8			.24		3.105	.971	.490			
13	11:26	987.2	92	82	328.1			.24		3.385	1.013	.490			
14	11:36	996.8	94	82	329.2			.24		3.387	1.014	.490			
15	11:46	006.5	94	82	330.3			.24		3.382	1.013	.490			
16	11:56	016.2	94	84	330.6			.24		3.387	1.015	.490			
17	12:06	025.9	94	84	331.3			.24		3.384	1.015	.490			
18	12:16	035.520	94	84	331.9			.24		3.381	1.014	.490			
		⟨160.670⟩	⟨84.44⟩		⟨320.6⟩				⟨2.77⟩		⟨.466⟩				

Down 23 min. ★

MOISTURE DATA	Initial	Final	Net
Impinger #1	~~100~~	~~0~~	~~71~~
Impinger #2	100	171	~~229~~
Impinger #3			
Impinger #4	~~200~~		
Silica Gel	200	~~242~~	~~42.5~~
TOTAL			112.5



FIELD CALCULATIONS	
Sample Vol. dscf =	
% H_2O =	
MWs =	
Stack Vel.(ft/s) =	
Flowrate(acfm) =	
Flowrate(dscfm) =	
Isokinetics (%) =	

COMMENTS: Cyclonic Dwell = Test Duration * COS / SUM COS

M501 & Cyclonic Dwell = Test Duration * (COS/AVG COS) * SQRT dP / Tot SQRT dP @ pts. sampled

WPCB Spike

00015

BEST ENVIRONMENTAL, INC. San Leandro, CA (510)278-4011

Isokinetic Sampling Data Sheet (Method 5G23)

Facility: LLNL **Date:** 8-26-98 **Run #:** 2 **Personnel:** P.R, DGJM, RE, MW

Facility Information		Equipment Information		Sampling Information	
Location: GSS Inlet RB#2		Meter #: 2	Pitot #: S-S	Pbar: 29.9	
Port Dia.:	Depth:	Yd: 1.0089	Cp: .94	Pstatic: -10	
Fitting:	Length:	ΔH@: 1.869	Noz. #: 56	% O_2:	
Stack Dia: 1.375	Area:	Filter Box #:	D_n: .304	% CO_2:	
Upstream from disturbance: 2		Filter #:	Mag. #:	% H_2O:	
Downstream from disturbance: 8		Probe #:	Umb. #:	Run Mins 180	
		Pyrometer #:			

Initial LC: .001 CFM@ 20 "Hg Final LC: .004 CFM@ 20 "Hg Pitot LC:

Point	Time	Gas Meter Vol, Ft³	Meter Temp, °F In	Meter Temp, °F Out	Stack Temp, °F	ΔP	ΔH	Meter ACFM	SQRT ΔP	Temp, °F Probe	Temp, °F Filter	Temp, °F Imp.	Vac., "Hg	Notes
		039.522												
1	13:09	047.8	92	80	335.8	.19	2.649	.897	.436			42		
2	13:19	055.8	92	82	336.7	.20	2.791	.921	.447					
3	13:29	063.0	88	82	337.5	.19	2.639	.894	.436					
4	13:39	068.8	86	82	338.0	.19	2.632	.892	.436					
5	13:49	074.5	90	82	338.4	.10	1.390	.652	.316					Down 12 min
6	14:14	085.7	98	82	337.1	.18	1.692	.721	.424					
7	14:24	092.4	94	82	337.6	.20	1.872	.757	.447					Down 2 min
8	14:36	099.8	90	82	337.6	.19	1.772	.735	.436					
9	14:46	107.4	90	82	338.4	.19	1.771	.735	.436					
10	14:56	115.1	90	82	339.7	.19	1.739	.728	.436					
11	15:06	122.5	88	82	338.7	.19	1.767	.733	.436					
12	15:16	128.4	88	82	339.6	.19	1.765	.733	.436					
13	15:26	136.0	94	82	339.4	.19	1.781	.740	.436					
14	15:36	143.6	96	84	339.8	.19	1.780	.740	.436					
15	15:46	150.3	90	82	339.9	.20	1.860	.753	.447					
16	15:56	156.4	94	84	340.7	.20	1.858	.753	.447					
17	16:06	161.3	86	82	341.1	.20	1.851	.750	.447					
18	16:16	168.323	88	82	340.7	.20	1.855	.751	.447					
		128.801	86.39		340.5		1.970		.432					

Moisture Data	Initial	Final	Net	Rinse
Impinger #1				
Impinger #2	100	214	114	
Impinger(s) #				
Impinger(s) #				
Silica Gel:	200	240	40	
Total Net / Rinse:			154	
Total Sample Volume:				

Field Calculations	
Sample Vol., dscf:	
% H_2O:	
MWs:	
MWd:	
Stack Vel, ft/s:	
Flow rate, acfm:	
Flow rate, dscfm:	
% Isokinetics:	

Comments:

BEST ENVIRONMENTAL, INC. San Leandro, CA (510)278-4011

Isokinetic Sampling Data Sheet (Method 423)

Facility: LLNL **Date:** 8-26-88 **Run #:** 3 **Personnel:** DC, MW

Facility Information		Equipment Information		Sampling Information	
Location: FILTER INLET		Meter #: LSI#2	Pitot #:	Pbar: 27.9	
Port Dia.:	Depth:	Yd: 1.0089	Cp:	Pstatic: -16	
Fitting:	Length:	ΔH@: 1.869	Noz. #: 5B	% O_2:	
Stack Dia: 14.375	Area:	Filter Box #:	D_n: .304	% CO_2:	
Upstream from disturbance: 2		Filter #:	Mag. #:	% H_2O:	
Downstream from disturbance: 8		Probe #:	Umb. #:	Run Mins	
		Pyrometer #:			

Initial LC: .001 CFM @ 20 "Hg Final LC: .004 CFM @ 20 "Hg Pitot LC:

Point	Time	Gas Meter Vol. Ft^3	Meter Temp. °F In	Meter Temp. °F Out	Stack Temp. °F	ΔP · .205	ΔH	Meter ACFM	SQRT ΔP	Temp. °F Probe	Temp. °F Filter	Temp. °F Imp.	Vac. "Hg	Notes
1	16:36	168.908	81	82	284	~~.284~~	1.965	.769	.453				17	
2	16:43:30	174.1	87	81	283	.20	1.923	.763	.447					
3	16:[illegible]		87	82	284	.195	1.879	.754	.442				17	
4	16:58:30	183.4	90	82	285	.195	1.932	.755	.442	–		–		
5	17:04	188.8	88	82	285	.19	1.830	.744	.436				17	
6	17:13:30	SHUT DOWN	85	82	286	.19	1.823	.742	.434					
7	17:28	189.343	84	81	287	.19	1.817	.740	.436				20	
8	17:25:30	198.3												
9	17:33	201.902	SHUT	DOWN										
10	17:42	201.902	81	81	290	.20	1.900	.755	.447				13	
11	17:49:30	208.1	90	91	287	.195	1.875	.754	.442				16	
12	17:57	214.1	92	81	289	.19	1.826	.744	.436					
13	18:04:30	219.9	92	82	290	.20	1.921	.764	.447					
14	18:16	225.7	91	82	292	.21	2.010	.781	.458				17	
15	18:23:30	230.6	89	82	293	.20	1.903	.760	.447				17	
16	18:31	235.5	88	82	293	.20	1.906	.760	.447					
17	18:38:30	239.9	87	82	294	.20	1.902	.758	.447				19	
18	18:46	243.7	86	82	295	.20	1.893	.757	.447					
19	18:53:30	248.0	86	82	296	.20	1.895	.757	.447				20	
20	19:01	252.3	85	81	298	.20	1.887	.754	.447				20	
21	19:08:30	256.6	85	81	297	.20	1.889	.755	.447				20	
22	19:16	260.395	~~85~~	~~81~~	~~300~~	~~.22~~								
23	19:24:30	264.6	85	81	300	.22	2.070	.790	.469				20	
24	19:32	268.1	85	81	300	.22	2.070	.790	.469					
25	19:39:30	271.7	84	81	300	.22	2.063	.789	.469				28	
26	19:47	275.4	86	81	301	.22	2.069	.790	.469				20	
27	19:54:30	278.6	86	81	301	.22	2.069	.790	.469				20	
STOP	20102	282.532												
		114.124	84.1		292.1		1.929		.450					

37:30

SD

SU

15 00

DOWN

4 MIN SHUT DOWN

SHUT ON 1 MIN

Moisture Data	Initial	Final	Net	Rinse
Impinger #1				
Impinger #2				
Impinger(s) #	100	196	96	
Impinger(s) #				
Silica Gel:	200	211	11	
Total Net / Rinse:			107	
Total Sample Volume:				

37:30
15
52:30
75
135

-1.5 @ 13:16

Field Calculations	
Sample Vol., dscf:	
% H_2O:	
MWs:	
MWd:	
Stack Vel, ft/s:	
Flow rate, acfm:	
Flow rate, dscfm:	
% Isokinetics:	

Comments:

BEST ENVIRONMENTAL, INC. San Leandro, CA (510)278-4011

Isokinetic Sampling Data Sheet (Method 1423)

Facility: LLNL **Date:** 8/26/98 **Run #:** 1 **Personnel:** DC

Facility Information		Equipment Information		Sampling Information	
Location: Cat. Out		Meter #: LS1-1	Pitot #: —	Pbar: 29.99	
Port Dia.:	Depth:	Yd: 1.0039	Cp: —	Pstatic: -2.5	
Fitting:	Length:	ΔH@: 2.196	Noz. #: 1	% O_2: 14	
Stack Dia: 4"	Area:	Filter Box #: —	D_n: .471	% CO_2: 5	
Upstream from disturbance:		Filter #: —	Mag. #: —	% H_2O: 5	
Downstream from disturbance:		Probe #: —	Umb. #: —	Run Mins: 180	
		Pyrometer #: —			

Initial LC: .006 CFM @ 16 "Hg Final LC: .004 CFM @ 10 "Hg Pitot LC:

Point	Time	Gas Meter Vol, Ft³	Meter Temp, °F In	Meter Temp, °F Out	Stack Temp, °F	ΔP	ΔH	Meter ACFM	SQRT ΔP	Temp, °F Probe	Temp, °F Filter	Temp, °F Imp.	Vac., "Hg	Notes
	1210	341.264	100	90	390		2.2						7	
	10		108	92										
	20		110	92										
	40		118	95										
	50		119	96										
	1300		121	98										
	1310		122	99										
	20		122	100										
	30		122	100										
40	40		122	100										
100	50		123	100										
	1400				↓									
	1410		123	101										
	1420		123	101										
	1430		123	101										
	1440		123	101										
	1450		123	101			↓						↓	
	1500		123	101										
Stop	1510	482.390												
		141.126	108.6											

Moisture Data	Initial	Final	Net	Rinse
Impinger #1	100	195	95	
Impinger #2				
Impinger(s) #				
Impinger(s) #				
Silica Gel:	200	225	25	
Total Net / Rinse:			120	
Total Sample Volume:				

Field Calculations	
Sample Vol., dscf:	
% H_2O:	
MWs:	
MWd:	
Stack Vel, ft/s:	
Flow rate, acfm:	
Flow rate, dscfm:	
% Isokinetics:	

Comments:

80

BEST ENVIRONMENTAL, INC. San Leandro, CA (510)278-4011

~~Isokinetic~~ Sampling Data Sheet (Method 0030)

Facility: LLNL MSO **Date:** 8-18-98 **Run #:** 1 **Personnel:** RB

Facility Information		Equipment Information		Sampling Information	
Location: Bayhouse Outlet		Meter #: 0490	Pitot #:	Pbar: 29.9	
Port Dia.: 4.375	Depth:	Yd: .9878	Cp:	Pstatic:	
Fitting:	Length:	ΔH@:	Noz. #: —	% O_2:	
Stack Dia: 1375	Area:	Filter Box #: —	D_n: —	% CO_2:	
Upstream from disturbance: 2		Filter #: —	Mag. #: —	% H_2O:	
Downstream from disturbance: 78		Probe #: —	Umb. # —	Run Mins	
		Pyrometer #:			

Initial LC: CFM @ "Hg Final LC: CFM @ "Hg Pitot LC: N/A

Point	Time	Gas Meter Vol. @ Yd	Meter Temp. °F In	Meter Temp. °F Out	Stack Temp. °F	~~Orifice~~ Setting	ΔH	Meter ACFM	SQRT ΔP	Temp. °F Probe	Temp. °F Filter	Temp. °F Imp.	Vac. "Hg	~~Notes~~ Imp.
(1) R1	1059	15.4	74	74		64								15a
	1104	21.0	74	73		5.1								12b
	1109	26.0	75	73		5.4								
	1114	31.2	76	73		5.5								
Stop	1114	35.2												L.C.
	1127	55.6	76	75		5.1								29 L.C.
	1132	70.1	78	75		5.2								26
	1137	85.0	78	75		5.3								
	1142	99.7	79	76		5.4								
F.O	1149	54.3												
	1155	54.6	78	77		5.5								39
	1200	59.5	80	77		5.4								36
	1205	64.4	80	77		5.2								
	1210	69.3	80	77		5.2								L.C.
End	1215	75.1												O.K.
		59.0	76.3											

Moisture Data	Initial	Final	Net	Rinse
Impinger #1				
Impinger #2				
Impinger(s) #				
Impinger(s) #				
Silica Gel:				
Total Net / Rinse:				
Total Sample Volume:				

Field Calculations	
Sample Vol., ~~dscf~~:	std liters = 58.2
% H_2O:	
MWs:	
MWd:	
Stack Vel, ft/s:	
Flow rate, acfm:	
Flow rate, dscfm:	
% Isokinetics:	

Comments: Field Blank Traps 15b 12a

BEST ENVIRONMENTAL, INC. San Leandro, CA (510)278-4011

Isokinetic Sampling Data Sheet (Method 0030)

Facility: LLNL MSO **Date:** 8-18-99 **Run #:** 2 **Personnel:** RB

Facility Information		Equipment Information		Sampling Information	
Location: A Doghouse Outlet		Meter #: 244	Pitot #:	Pbar:	
Port Dia.:	Depth:	Yd: 0.981X	Cp:	Pstatic:	
Fitting:	Length:	ΔH@:	Noz. #:	% O_2:	
Stack Dia:	Area:	Filter Box #:	D_n:	% CO_2:	
Upstream from disturbance: 2		Filter #:	Mag. #:	% H_2O:	
Downstream from disturbance: 7.8		Probe #:	Umb. #	Run Mins	
		Pyrometer #:			

Initial LC: CFM @ "Hg Final LC: CFM @ "Hg Pitot LC:

Point	Time	Dry Gas Meter Vol. Ft³	Meter Temp. °F In	Meter Temp. °F Out	Stack Temp. °F	Orifice ΔH	ΔH	Meter ACFM	SQRT ΔP	Temp. °F Probe	Temp. °F Filter	Temp. °F Imp.	Vac. "Hg	Notes
	1234	75.1	78	76		5.1								49 L.C OK
	1239	80.8	77	76		5.2								66
	1244	85.5	79	77		5.2								
	1249	90.5	80	76		5.2								
End	1254	95.0												L.C.OK
	1301	95.2	78	76		5.4								59
	1306	99.2	79	76		5.4								56
	1311	103.2	79	76		5.1								
	1316	107.3	80	76		5.2								
End	1321	111.6												L.C.OK
	1330	111.8	78	76		5.1								L.C.OK
	1335	116.0	80	77		5.2								64
	1340	121.2	80	77		5.3								60
	1345	126.2	80	77		5.3								
End	1350	131.2												
		55.7	77.7											

Moisture Data	Initial	Final	Net	Rinse
Impinger #1				
Impinger #2				
Impinger(s) #				
Impinger(s) #				
Silica Gel:				
Total Net / Rinse:				
Total Sample Volume:				

Field Calculations	
Sample Vol., dscf:	
% H_2O:	
MWs:	
MWd:	
Stack Vel, ft/s:	
Flow rate, acfm:	
Flow rate, dscfm:	
% Isokinetics:	

Comments: New Cond.

~~Isokinetic~~ Sampling Data Sheet (Method 0030)

Facility: LLNL **Date:** 8-18-98 **Run #:** 3 **Personnel:** BB

Facility Information		Equipment Information		Sampling Information	
Location: 580 house Duct		Meter #: 500	Pitot #:	Pbar:	
Port Dia.:	Depth:	Yd: .9818	Cp:	Pstatic:	
Fitting:	Length:	ΔH@:	Noz. #:	% O_2:	
Stack Dia:	Area:	Filter Box #:	D_n:	% CO_2:	
Upstream from disturbance:		Filter #:	Mag. #:	% H_2O:	
Downstream from disturbance:		Probe #:	Umb. #	Run Mins	
		Pyrometer #:			

Initial LC: CFM @ "Hg Final LC: CFM @ "Hg Pitot LC:

Point	Time	Gas Meter Vol. Ft³	Meter Temp. °F In	Meter Temp. °F Out	Stack Temp. °F	~~Imp~~ condensor	ΔH	Meter ACFM	SQRT ΔP	Temp. °F Probe	Temp. °F Filter	Temp. °F Imp.	Vac. "Hg.	Notes ~~Traps~~
	1404	136.7	76	75		50								89
	1409	136.4	77	76		49								80
	1084	141.1	78	76		50								
	1437	145.6	79	76		51								
	1444	150.3												LCOK
	1456	150.6	76	76		52								LCOK
	1501	154.9	78	76		52								99
	1506	159.2	79	76		52								96
	1511	163.5	79	76		52								
	1516	169.0												
														LCOK
	1526	169.2	79	77		51								109
	1531	174.0	79	77		51								106
	1536	179.1	80	77		52								
	1541	184.3	80	77		52								
	1546	188.5												LCOK
		56.3	77.3											

Moisture Data	Initial	Final	Net	Rinse
Impinger #1				
Impinger #2				
Impinger(s) #				
Impinger(s) #				
Silica Gel:				
Total Net / Rinse:				
Total Sample Volume:				

Field Calculations	
Sample Vol., dscf:	
% H_2O:	
MWs:	
MWd:	
Stack Vel., ft/s:	
Flow rate, acfm:	
Flow rate, dscfm:	
% Isokinetics:	

Comments:

000199

C:\forms\field\usa.xls

BEST ENVIRONMENTAL, INC.

Isokinetic Sampling Data Sheet (Method 0030)

Facility: LLNL MSD **Date:** 8-18-98 **Run #:** 1 **Personnel:** BR

Facility Information		Equipment Information		Sampling Information	
Location: Catalyst Outlet		Meter #:	Pitot #:	Pbar:	
Port Dia.:	Depth:	Yd:	Cp:	Pstatic:	
Fitting:	Length:	ΔH@:	Noz. #:	% O_2:	
Stack Dia:	Area:	Filter Box #:	D_n:	% CO_2:	
Upstream from disturbance:		Filter #:	Mag. #:	% H_2O:	
Downstream from disturbance:		Probe #:	Umb. #	Run Mins	
		Pyrometer #:			

Initial LC: CFM @ "Hg Final LC: CFM @ "Hg Pitot LC:

Point	Time	Gas Meter Vol. Ft³	Meter Temp. °F In	Meter Temp. °F Out	Stack Temp. °F	ΔP Orifice	ΔH	Meter ACFM	SQRT ΔP	Temp. °F Probe	Temp. °F Filter	Temp. °F Imp.	Vac. "Hg	Notes
	1619	188.9	79	78		51								Trax
	1619		80	79		51								11a
1633	~~1634~~	197.9	80	79		52								11b
1640	~~1639~~	203.5	80	79		53								LC OK
1645 End	~~1654~~	209.2												
														LC OK
	1652	209.5	79	78		53								13a
	1657	214.0	79	78		54								13b
	1702	219.6	80	78		53								
	1707	224.6	80	78		55								LC OK
End	1712	229.7												
	1720	230.2	81	80		56								14a
	1725	235.3	82	80		56								14b
	1730	240.4	82	80		57								
	1735	245.5	82	80		57								
End	1740	250.7												LC OK
		61.1	79.6											

Moisture Data	Initial	Final	Net	Rinse
Impinger #1				
Impinger #2				
Impinger(s) #				
Impinger(s) #				
Silica Gel:				
Total Net / Rinse:				
Total Sample Volume:				

Field Calculations	
Sample Vol., dscf:	
% H_2O:	
MWs:	
MWd:	
Stack Vel., ft/s:	
Flow rate, acfm:	
Flow rate, dscfm:	
% Isokinetics:	

Comments: Problem with feed 1600-1630

000120

G:\forms\field\isos.xls

42

CARB Method 5 / 501 / Cyclonic

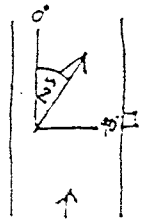
Facility: LLNL MSO Date: 8-26-99 Method: 0030 Run #: 1

Facility Information		Equipment		Sampling Data	
Location: Filter Outlet		Meter #: 2900	Pitot #:	PBar:	P Static:
Port Dia.	Depth:	Meter Yd:	Pitot Cp:	%O_2 Ass.	%O_2 Actual:
Fitting Type:	Length:	ΔH@:	Noz. #:	%CO_2 Ass.	%CO_2 Actual:
Stack Dia. 1.525	Area:	Filter #:	Noz. Dia.	%H_2O Ass.	Pitot LC:
Upstream Dist.		Probe #:		Test Mins.	Personnel:
Downstream Dist.		Initial LC: ____ CFM @ ____ "Hg		Final LC: ____ CFM @ ____ "Hg	

L.C. Ives

Point	Clock Time	Gas Meter	Meter °F Inlet	Meter °F Outlet	Stack Temp °F	Cyclonic Angle	Cos	ΔP	Avg ΔP @ pts.	ΔH setting	Meter CFM	SQRT ΔP	Imp °F	Vac. "Hg	Dwell Mins.
	0903	606.130	72	72										L.C.OK	239
	0908	610.4	73	72											236
	0913	618.0	74	72											
	0918	623.1	76	73											
End	0923	628.3													
	0928													L.C.OK	
														L.C.OK	
	0934	628.7	76	74											229
	0939	633.2	77	74											226
	0944	637.8	78	74											
	0949	643.6	77	76											
End	0954	648.9												L.C.OK	
														L.C.OK	
	1004	654.2	78	76											216
	1009	659.2	79	76											216
	1014	659.4	80	77											
	1019	664.4	80	77										L.C. OK	
End	1024	669.8													
	0	670.0													
		56.1	76												

MOISTURE DATA	Initial	Final	Net
Impinger #1			
Impinger #2			
Impinger #3			
Impinger #4			
Silica Gel			
TOTAL			



FIELD CALCULATIONS	
Sample Vol. dscf =	
% H_2O =	
MWs =	
Stack Vel.(ft/s) =	
Flowrate(acfm) =	
Flowrate(dscfm) =	
Isokinetics (%) =	

COMMENTS: Cyclonic Dwell = Test Duration * COS / SUM COS

M501 & Cyclonic Dwell = Test Duration * (COS/AVG COS) * SQRT dP / Tot SQRT dP @ pts. sampled

Trips 1&4/1&t Field blank

000171

83

CARB Method 5 / 501 / Cyclonic

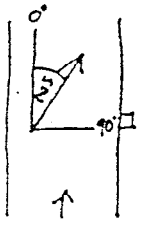
Facility: LLNL 850 Date: 8-26-98 Method: 0036 Run #: 2

Facility Information		Equipment		Sampling Data	
Location: Filter Outlet		Meter #: 2400	Pitot #: —	PBar:	P Static:
Port Dia.	Depth:	Meter Yd:	Pitot Cp: ~	%O_2 Ass.	%O_2 Actual:
Fitting Type:	Length:	ΔH@:	Noz. #: ~	%CO_2 Ass.	%CO_2 Actual:
Stack Dia. 1.375	Area:	Filter #:	Noz. Dia. ~	%H_2O Ass.	Pitot LC:
Upstream Dist. 2		Probe #:		Test Mins.	Personnel:
Downstream Dist. 8		Initial LC: _____ CFM @ ____ "Hg		Final LC: _____ CFM @ ____ "Hg	

Tapes

Point	Clock Time	Gas Meter Vol.	Meter °F Inlet	Meter °F Outlet	Stack Temp °F	Cyclonic Angle	Cos	ΔP	Avg ΔP @ pts.	ΔH setting	Meter CFM	SQRT ΔP	Imp °F	Vac. "Hg	Dwell Mins.
	1048	670.0	78	75									L.C. OK		209 206
	1053	675.0	79	76											
	1058	680.5	80	76											
	1103	685.5	81	77									L.C. OK		
End	1108	690.4													
	1119	690.8	78	76									L.C. OK		190 196
	1124	695.8	80	77											
	1129	700.8	81	78											
	1134	706.0	82	78									L.C. OK		
End	1139	711.2													
	1150	711.4	80	78									L.C. OK		180 186
	1155	716.3	81	78											
	1200	721.2	82	78											
	1205	725.8	82	78									L.C. OK		
End	1210	730.8													
		60.1	78.7												

MOISTURE DATA	Initial	Final	Net
Impinger #1			
Impinger #2			
Impinger #3			
Impinger #4			
Silica Gel			
TOTAL			



FIELD CALCULATIONS	
Sample Vol. dscf =	
% H_2O =	
MWs =	
Stack Vel. (ft/s) =	
Flowrate(acfm) =	
Flowrate(dscfm) =	
Isokinetics (%) =	

COMMENTS: Cyclonic Dwell = Test Duration * COS / SUM COS

M501 & Cyclonic Dwell = Test Duration * (COS/AVG COS) * SQRT dP / Tot. SQRT dP @ pts. sampled

BEST ENVIRONMENTAL, INC. San Leandro, CA (510)278-4011

Isokinetic Sampling Data Sheet (Method 0030)

Facility: LLNL HWF **Date:** 8-26-98 **Run #:** 3 **Personnel:** RB

Facility Information		Equipment Information		Sampling Information	
Location: Filter Outlet		Meter #: 2400	Pitot #:	Pbar:	
Port Dia.:	Depth:	Yd:	Cp:	Pstatic:	
Fitting:	Length:	ΔH@:	Noz. #:	% O_2:	
Stack Dia:	Area:	Filter Box #:	D_n:	% CO_2:	
Upstream from disturbance:		Filter #:	Mag. #:	% H_2O:	
Downstream from disturbance:		Probe #:	Umb. #	Run Mins	
		Pyrometer #:			

Initial LC: CFM @ °Hg Final LC: CFM @ °Hg Pitot LC:

Temp

Point	Time	Gas Meter Vol, Ft³	Meter Temp, °F In	Meter Temp, °F Out	Stack Temp, °F	ΔP	ΔH	Meter ACFM	SQRT ΔP	Temp, °F Probe	Temp, °F Filter	Temp, °F Imp.	Vac., "Hg	Notes
	1229	731.0	78	76										L.C.OK 179
	1234	736.0	79	76										176
	1239	741.0	80	77										
	1244	746.0	81	77										
End	1249	751.0												L.C.OK
	1259	751.2	79	77										L.C.OK 168
	1304	756.2	80	77										166
	1309	761.2	82	78										
	1314	766.2	82	78										
End	1319	771.3												L.C.OK 0.805
														L.C.OK 19
	1328	771.6	80	78										16
	1333	776.7	81	78										
	1338	781.8	82	78										
	1343	787.0	82	78										
End	1348	792.5												L.C.OK
		61.0	1.9											

Moisture Data	Initial	Final	Net	Rinse
Impinger #1				
Impinger #2				
Impinger(s) #				
Impinger(s) #				
Silica Gel:				
Total Net / Rinse:				
Total Sample Volume:				

Field Calculations	
Sample Vol., dscf:	
% H_2O:	
MWs:	
MWd:	
Stack Vel, ft/s:	
Flow rate, acfm:	
Flow rate, dscfm:	
% Isokinetics:	

Comments:

00017

84

Isokinetic Sampling Data Sheet (Method 0030)

Facility: LLNL MSO **Date:** 8-26-99 **Run #:** 1 **Personnel:** DPT

Facility Information		Equipment Information		Sampling Information	
Location: Catalyst Outlet		Meter #: 2400	Pitot #:	Pbar:	
Port Dia.:	Depth:	Yd:	Cp:	Pstatic:	
Fitting:	Length:	ΔH@:	Noz. #:	% O_2:	
Stack Dia:	Area:	Filter Box #:	D_n:	% CO_2:	
Upstream from disturbance:		Filter #:	Mag. #:	% H_2O:	
Downstream from disturbance:		Probe #:	Umb. #	Run Mins:	
		Pyrometer #:			

Initial LC: CFM @ °Hg Final LC: CFM @ °Hg Pitot LC:

Point	Time	Gas Meter Vol. Ft³	Meter Temp. °F In	Meter Temp. °F Out	Stack Temp. °F	ΔP	ΔH	Meter ACFM	SQRT ΔP	Temp. °F Probe	Temp. °F Filter	Temp. °F Imp.	Vac. "Hg	Notes
	1410	772.6	78	78										L.C. OK
	1415	797.8	79	78										
	1420	803.2	80	78										
	1425	808.8	80	78										
End	1430	813.7												L.C. OK
	1440	819.2	80	78										L.C. OK
	1445	828.0	82	79										
	1450	833.6	82	80										
	1455	838.4	82	80										
End	1500	843.3												L.C. OK
	1510	833.8	80	80										L.C. OK
	1515	838.8	82	80										
	1520	843.6	82	80										
	1525	848.5	83	81										
End	1530	853.3												L.C. OK
		59.7	80.0											

Moisture Data	Initial	Final	Net	Rinse
Impinger #1				
Impinger #2				
Impinger(s) #				
Impinger(s) #				
Silica Gel:				
Total Net / Rinse:				
Total Sample Volume:				

Field Calculations	
Sample Vol., dscf:	
% H_2O:	
MWs:	
MWd:	
Stack Vel, ft/s:	
Flow rate, acfm:	
Flow rate, dscfm:	
% Isokinetics:	

Comments:

BEST ENVIRONMENTAL, INC. San Leandro, CA (510)278-4011

Isokinetic Sampling Data Sheet (Method 5/114)

Facility: LLNL **Date:** 8/18/98 **Run #:** 1 **Personnel:** Jay, P.R., RB, MW, DC

Facility Information	Equipment Information	Sampling Information
Location: FILTER OUTLET	Meter #: ASI #3 Pitot #:	Pbar: 29.9
Port Dia.: Depth:	Yd: .9593 Cp: .91	Pstatic: -11.5
Fitting: Length:	ΔH@: 1.684 Noz. #: S #6A	% O_2: 14
Stack Dia: 1.375 Area:	Filter Box #: #3 D_n: .378	% CO_2: 8
Upstream from disturbance: >3<8	Filter #: 881 Mag. #:	% H_2O: 10
Downstream from disturbance: <8	Probe #: Umb. #	Run Mins: 60
	Pyrometer #:	

Initial LC: .002 CFM @ 25 "Hg Final LC: .004 CFM @ 22 "Hg Pitot LC:

Point	Time	Gas Meter Vol, Ft³	Meter Temp, °F In	Meter Temp, °F Out	Stack Temp, °F	ΔP	ΔH	Meter ACFM	SQRT ΔP	Temp, °F Probe	Temp, °F Filter	Temp, °F Imp.	Vac. "Hg.	Notes
1	10:27	751.418	65	64	196	.167	3.158	1.002	.409				10	
2	10:34:30	759.0	75	65	194	.195	3.681	1.035	.442				12	
3	10:42	767.3	83	70	196	.19	3.619	1.033	.436				12	
4	10:49:30	774.6	89	75	197	.19	3.651	1.043	.436				12	
5	10:57	783.9	92	80	201	.18	3.463	1.069	.424				11	
6	11:04:30	792.4	93	83	203	.185	3.561	1.086	.430				11	
7	11:12	800.7	95	86	207	.205	3.941	1.144	.453				125	
8	11:19:30	809.4	96	87	210	.22	4.213	1.194	.469				13	
Stop	11:27	818.496												
		67.078	81.1		199.4		3.66		.437					

Moisture Data	Initial	Final	Net	Rinse
Impinger #1	100	157		
Impinger #2	100	103		
Impinger(s) #				
Impinger(s) #				
Silica Gel:	333	17.1		
Total Net / Rinse:			94.1	
Total Sample Volume:				

Field Calculations	
Sample Vol., dscf:	62.946
% H_2O:	5.5
MWs:	
MWd:	
Stack Vel, ft/s:	
Flow rate, acfm:	
Flow rate, dscfm:	
% Isokinetics:	

Comments: LINE RINSE 30 mL

000175

G:\forms\field\isos.xls

85

BEST ENVIRONMENTAL, INC. San Leandro, CA (510)278-4011

Isokinetic Sampling Data Sheet (Method 5/114)

Facility: LAWRENCE LIVERMORE **Date:** 8-18-98 **Run #:** 2 **Personnel:**

Facility Information		Equipment Information		Sampling Information	
Location: BAGHOUSE OUTLET		Meter #: ASI#8	Pitot #: MINI STD.	Pbar: 29.9	
Port Dia.:	Depth:	Yd: .9593	Cp: .99	Pstatic: -11.5	
Fitting:	Length:	ΔH@: 1.684	Noz. #: 6A	% O_2: 14	
Stack Dia: 1.375	Area: 0.01	Filter Box #: 2	D_n: .378	% CO_2: 8	
Upstream from disturbance: <8		Filter #: 882	Mag. #:	% H_2O: 5.5	
Downstream from disturbance: <8		Probe #:	Umb. #:	Run Mins: 60	
		Pyrometer #:			

Initial LC: .005 CFM@ 15 "Hg Final LC: .004 CFM@ 23 "Hg Pitot LC:

Point	Time	Gas Meter Vol, Ft³	Meter Temp, °F In	Meter Temp, °F Out	Stack Temp, °F	ΔP	ΔH	Meter ACFM	SQRT ΔP	Temp, °F Probe	Temp, °F Filter	Temp, °F Imp.	Vac., "Hg	Notes
1	12:45	819.745	69	69	228	.18	3.490	1.057	.424				10	
2	13:52:30	823.0	78	71	231	.175	3.414	1.051	.418				10	
3	13:00	826.0	87	74	233	.19	3.737	1.104	.436				10.5	
4	13:07:30	849.7	92	80	235	.19	3.764	1.114	.436					
5	13:15	853.2	96	86	233	.195	3.882	1.136	.442				10.5	
6	13:22:30	861.9	98	86	240	.19	3.779	1.122	.436				10.5	
7	13:30	870.6	100	89	243	.225	4.476	1.222	.474				12	
8	13:37:30	879.3	102	91	245	.20	3.931	1.156	.447				11	
stop	13:45	888.566												
		63.321	95.5		236.4		3.815		.439					

Moisture Data	Initial	Final	Net	Rinse
Impinger #1	100	163*	33	
Impinger #2	100	109	9	
Impinger(s) #				
Impinger(s) #				
Silica Gel:	200	213.4	13.4	
Total Net / Rinse:			55.4	
Total Sample Volume:			0.0554 m³	

Imp. = 42

Field Calculations	
Sample Vol., dscf:	64.896
% H_2O:	3.95
MWs:	29.38
MWd:	
Stack Vel, ft/s:	33.573
Flow rate, acfm:	20.74
Flow rate, dscfm:	14.9
% Isokinetics:	96.9

Comments: * 31 ML IN LINE RINSE INCLUDED

000176

G:\forms\field\isos.xls

BEST ENVIRONMENTAL, INC. San Leandro, CA (510)278-4011

Isokinetic Sampling Data Sheet (Method 5/114)

Facility: LAWRENCE LIVERMORE **Date:** 8-18-98 **Run #:** 3 **Personnel:** JM-DC-PR-MW-RL

Facility Information		Equipment Information		Sampling Information	
Location:	BAGHOUSE OUTLET	Meter #:	ASI #3 Pitot #: MINI STD.	Pbar:	29.9
Port Dia.:	Depth:	Yd:	.9593 Cp: .99	Pstatic:	-11.5
Fitting:	Length:	ΔH@:	1.694 Noz. #: 6A	% O_2:	14
Stack Dia:	1.375 Area: 0.01	Filter Box #:	2 D_n: .373	% CO_2:	8
Upstream from disturbance:	<8	Filter #:	Q245 Mag. #:	% H_2O:	3.95
Downstream from disturbance:	<8	Probe #:	Umb. #	Run Mins:	60
		Pyrometer #:			

Initial LC: .004 CFM@ 21 "Hg Final LC: .006 CFM@ 20 "Hg Pitot LC:

Point	Time	Gas Meter Vol, Ft^3	Meter Temp, °F In	Meter Temp, °F Out	Stack Temp, °F	ΔP	ΔH	Meter ACFM	SQRT ΔP	Temp, °F Probe	Temp, °F Filter	Temp, °F Imp.	Vac. "Hg	Notes
1	15:00	889.794	70	71	254	.18	3.465	1.054	.424				11	
2		893.9	81	72	257	.185	3.587	1.073	.430				11	
3	15:15	906.3	89	76	261	.18	3.509	1.073	.424				11	
4		914.4	93	80	260	.18	3.540	1.081	.424				11	
5	15:30	923.0	95	84	262	.18	3.550	1.082	.424				11	
6		931.2	97	86	263	.18	3.553	1.089	.424				11	
7	15:45	939.6	93	88	265	.18	3.557	1.090	.424				11	
8		948.2	99	90	230	.165	3.203	1.037	.406				10	
STOP	16:00	956.546												
		66.752	85.6		262.3		3.496		423					

Moisture Data	Initial	Final	Net	Rinse
Impinger #1	150	164.8	34	
Impinger #2	100	102	2	
Impinger(s) #				
Impinger(s) #				
Silica Gel:	200	213.4	14.4	
Total Net / Rinse:			50.4	
Total Sample Volume:			730	

Field Calculations	
Sample Vol., dscf:	62.389
% H_2O:	3.7
MWs:	29.40
MWd:	
Stack Vel, ft/s:	32.86
Flow rate, acfm:	20.35
Flow rate, dscfm:	14.0
% Isokinetics:	99.2

Comments: 30 ML of LINE RINSE

000177

G:\forms\field\isodata

80

Isokinetic Sampling Data Sheet (Method 5/114)

Facility: LCNL **Date:** 8/19/98 **Run #:** 1 **Personnel:** DC

Facility Information		Equipment Information		Sampling Information	
Location: Cat. Out		Meter #: L51-1	Pitot #: Std	Pbar: 29.9	
Port Dia.: 1"	Depth: 0	Yd: 1.0039	Cp: .99	Pstatic: -2.5	
Fitting: 0	Length: 0	ΔH@: 2.196	Noz. #: 41	% O_2:	
Stack Dia: 4"	Area:	Filter Box #: -	D_n: .752	% CO_2:	
Upstream from disturbance:		G Filter #: 822	Mag. #:	% H_2O:	
Downstream from disturbance:		Probe #: -	Umb. #	Run Mins 60	
		Pyrometer #: -			

Initial LC: .001 CFM @ 10 "Hg Final LC: .001 CFM @ 10 "Hg Pitot LC:

Point	Time	Gas Meter Vol. Ft³	Meter Temp. °F In	Meter Temp. °F Out	Stack Temp. °F	ΔP	ΔH	Meter ACFM	SQRT ΔP	Temp. °F Probe	Temp. °F Filter	Temp. °F Imp.	Vac. "Hg	Notes
	933	267.077	88	74	385	.005	1.8	.69					6	
		270.5	96	78	385	.004	1.5	.62					5	
10	943	273.6	98	79	420	.004	1.4	.61					5	
		276.7	100	80	420	.004	1.4	.61					5	
20	953	279.8	104	84	401	.004	1.5	.62					5	
		282.9	109	86	401	.003	1.6	.63					5	
30	1003	286.1	112	88	401	.004	1.5	.63					5	
		289.3	112	88	401	.004	1.5	.63					5	
40	1013	292.4	114	90	401	.004	1.5	.63					5	
		295.6	116	92	401	.004	1.5	.63						
50	1023	298.8	118	94	401	.004	1.5	.64						
		301.9	119	95	401	.004	1.5	.64						
Stop	1033	305.062												
		27.985	96.4		401.5		1.5		.634					

Moisture Data	Initial	Final	Net	Rinse
Impinger #1	100	98	-2	20
Impinger #2	100	100		
Impinger(s) #				
Impinger(s) #				
Silica Gel:	200	209	9	
Total Net / Rinse:			207	
Total Sample Volume:			1219	

Field Calculations	
Sample Vol., dscf:	
% H_2O:	
MWs:	
MWd:	
Stack Vel, ft/s:	
Flow rate, acfm:	
Flow rate, dscfm:	
% Isokinetics:	

Comments:

000175

G:\forms\field\isa.xls

BEST ENVIRONMENTAL, INC. San Leandro, CA (510)278-4011

Isokinetic Sampling Data Sheet (Method 17/114)

Facility: LAWRENCE LIVERMORE **Date:** 8-26-98 **Run #:** 1 **Personnel:** JM-RB-DC-PR

Facility Information		Equipment Information		Sampling Information	
Location:	FILTER OUTLET	Meter #:	ASI#8	Pitot #:	M101 STD
Port Dia.:		Depth:		Yd:	.9593
Fitting:		Length:		Cp:	.99
Stack Dia:	1.375	Area:	0.01	ΔH@:	1.684
Upstream from disturbance:	3			Noz. #:	5E
Downstream from disturbance:	>8			Filter Box #:	—
				D_n:	.309
				Filter #:	929
				Mag. #:	—
				Probe #:	—
				Umb. #:	—
				Pyrometer #:	—
				Pbar:	29.9
				Pstatic:	-10.0
				% O_2:	
				% CO_2:	
				% H_2O:	5.0
				Run Mins	60

Initial LC: .01 CFM @ 1.5 "Hg Final LC: .008 CFM @ 1.1 "Hg Pitot LC:

Point	Time	Gas Meter Vol, Ft³	Meter Temp, °F In	Meter Temp, °F Out	Stack Temp, °F	ΔP	°ΔH	Meter ACFM	SQRT ΔP	Temp, °F Probe	Temp, °F Filter	Temp, °F Imp.	Vac., "Hg	Notes
1	9:10	958.352	68	69	296	.165	1.314	.653	.406					
2	9:17:30	963.6	76	69	302	.17	1.354	.665	.412					
3	9:25	969.0	81	72	307	.17	1.355	.668	.412					
4	9:32:30	974.3	84	75	309	.175	1.399	.680	.418					
5	9:40	979.8	86	78	311	.22	1.762	.765	.469					
6	9:47:30	985.8	88	81	312	.19	1.527	.714	.436				4	
7	9:55	991.7	89	83	314	.20	1.608	.733	.447				4	
8	10:02:30	997.6	89	84	316	.24	1.926	.803	.490					
FOP	10:10	1003.976												
		45.524	79.5		308.4		1.531		.436					

Moisture Data	Initial	Final	Net	Rinse
Impinger #1	100	169	69	
Impinger #2	100	103	3	
Impinger(s) #				
Impinger(s) #				
Silica Gel:	200.2	212.3	12.0	
Total Net / Rinse:			74.6	
Total Sample Volume:				

Field Calculations	
Sample Vol., dscf:	43.035
% H_2O:	8.5
MWs:	28.79
MWd:	
Stack Vel, ft/s:	35.35
Flow rate, acfm:	21.86
Flow rate, dscfm:	13.4
% Isokinetics:	105.6

Comments: 4 on 7

000170

87

BEST ENVIRONMENTAL, INC. San Leandro, CA (510)278-4011

Isokinetic Sampling Data Sheet (Method 17/114)

Facility: LAWRENCE LIVERMORE **Date:** 8-26-98 **Run #:** 2 **Personnel:** SM-KB-DC-PR

Facility Information		Equipment Information		Sampling Information	
Location: FILTER OUTLET		Meter #: ASI #8	Pitot #: MWI-STD	Pbar: 29.9	
Port Dia.:	Depth:	Yd: .9593	Cp: .99	Pstatic: -.10	
Fitting:	Length:	ΔH@: 1.634	Noz. #: 5E	% O_2:	
Stack Dia: 1.375	Area: 0.01	Filter Box #:	D_n: .309	% CO_2:	
Upstream from disturbance: 3		Filter #: 831	Mag. #:	% H_2O: 5.0	
Downstream from disturbance: >8		Probe #:	Umb. #:	Run Mins: 60	
		Pyrometer #:			

Initial LC: .004 CFM@ 10 "Hg Final LC: .003 CFM@ 11 "Hg Pitot LC:

Point	Time	Gas Meter Vol. Ft³	Meter Temp. °F In	Meter Temp. °F Out	Stack Temp, °F	ΔP	ΔH	Meter ACFM	SQRT ΔP	Temp, °F Probe	Temp, °F Filter	Temp, °F Imp.	Vac. "Hg	Notes
1	11:00	004.310	69	70	323	.215	1.657	.733	.464				4	
2	11:07:30	010.1	77	71	325	.225	1.744	.755	.474				4	
3	11:15	016.0	81	73	326	.24	1.863	.784	.490				4	
4	11:22:30	022.2	85	76	327	.24	1.878	.788	.490				4	
5	11:30	029.5	87	80	329	.235	1.847	.784	.485					
6	11:37:30	034.7	89	81	329	.235	1.850	.786	.485				4	
7	11:45	041.2	90	84	330	.24	1.894	.796	.490				4	
8	11:52:30	047.4	91	85	331	.235	1.855	.799	.485				4	
STOP	12:00	053.753												
		49.443	80.6		327.4		1.824		.483					

Moisture Data	Initial	Final	Net	Rinse
Impinger #1	100	150	50	
Impinger #2	100	103	3	
Impinger(s) #				
Impinger(s) #				
Silica Gel:	200	212	12	
Total Net / Rinse:			65	30.35 ml rinse
Total Sample Volume:				

Field Calculations	
Sample Vol., dscf:	46.691
% H_2O:	6.2
MWs:	29.07
MWd:	
Stack Vel, ft/s:	39.38
Flow rate, acfm:	24.36
Flow rate, dscfm:	15.0
% Isokinetics:	102.7

Comments: 30 ml line rinse

000150

G:\forms\field\isa.xls

BEST ENVIRONMENTAL, INC. San Leandro, CA (510)278-4011

Isokinetic Sampling Data Sheet (Method 17/114)

Facility: LAWRENCE LIVERMORE **Date:** 8-24-98 **Run #:** 3 **Personnel:** JM-RB-DC-PR-MW

Facility Information		Equipment Information		Sampling Information	
Location:	FILTER OUTLET	Meter #:	ASI #3	Pbar:	29.9
Port Dia.:		Pitot #:	MINI STD	Pstatic:	-10.0
Depth:		Yd:	.9593	% O_2:	9.75
Fitting:		Cp:	.99	% CO_2:	7.5
Length:		ΔH@:	1.634	% H_2O:	
Stack Dia:	1.375	Noz. #:	5E	Run Mins:	60
Area:	0.01	Filter Box #:			
Upstream from disturbance:	3	D_n:	.309		
Downstream from disturbance:	>8	Filter #:	832		
		Mag. #:			
		Probe #:			
		Umb. #:			
		Pyrometer #:			

Initial LC: .004 CFM @ 4 "Hg Final LC: .005 CFM @ 10 "Hg Pitot LC:

Point	Time	Gas Meter Vol. Ft³	Meter Temp. °F In	Meter Temp. °F Out	Stack Temp. °F	ΔP	ΔH	Meter ACFM	SQRT ΔP	Temp. °F Probe	Temp. °F Filter	Temp. °F Imp.	Vac. "Hg	Notes
1	12:45	054.421	71	72	332	.20	1.499	.699	.447				4	
2	12:52:30	060.0	78	73	333	.22	1.659	.738	.469				4	
3	13:00	066.0	83	75	334	.20	1.516	.708	.447				4	
4	13:07:30	071.7	86	78	335	.19	1.447	.693	.436				4	
5	13:15	077.3	88	80	336	.19	1.450	.696	.436				4	
6	13:22:30	083.0	89	83	337	.19	1.454	.698	.436				4	
7	13:30	088.5	90	84	337	.19	1.456	.699	.436				4	
8	13:37:30	094.4	90	85	338	.19	1.456	.699	.436				4	
Stop	13:45	099.965												
		45.484	81.0		335.3		1.492		.443					

Moisture Data	Initial	Final	Net	Rinse
Impinger #1	100	157	57	
Impinger #2	100	183	83	
Impinger(s) #				
Impinger(s) #				
Silica Gel:	200	210.3	10.3	
Total Net / Rinse:			150.3	-50 =
Total Sample Volume:				

150.3 net

Field Calculations	
Sample Vol., dscf:	42.329
% H_2O:	7.2
MWs:	28.95
MWd:	
Stack Vel, ft/s:	36.35
Flow rate, acfm:	22.51
Flow rate, dscfm:	13.6
% Isokinetics:	104.2

Comments: 50 ml RAE rinse

000191

8

Isokinetic Sampling Data Sheet (Method M17/114)

Facility: LAWRENCE LIVERMORE **Date:** 8-26-98 **Run #:** 1 **Personnel:** DC, JM

Facility Information		Equipment Information		Sampling Information	
Location: CATALYST OUTLET		Meter #: LSI #1	Pitot #:	Pbar:	
Port Dia.: –	Depth: –	Yd: 1.0039	Cp:	Pstatic: -2.5	
Fitting: –	Length: –	ΔH@: 2.196	Noz. #:	% O_2:	
Stack Dia: 4"	Area:	Filter Box #: LSI-1	D_n:	% CO_2:	
Upstream from disturbance: 8		Filter #: 828	Mag. #:	% H_2O:	
Downstream from disturbance: 8		Probe #: –	Umb. #:	Run Mins: 60	
		Pyrometer #:			

Initial LC: .004 CFM @ 15 "Hg Final LC: .004 CFM @ 10 "Hg Pitot LC:

Point	Time	Gas Meter Vol. Ft^3	Meter Temp. °F In	Meter Temp. °F Out	Stack Temp. °F	ΔP	ΔH	Meter ACFM	SQRT ΔP	Temp. °F Probe	Temp. °F Filter	Temp. °F Imp.	Vac. "Hg	Notes
	1040													
1	1042	305.674	80	74	390	.004	1.3	.57					5	
2	1047	310.1	~~88~~ 90	76	390	.004	1.3	.58					5	
3	1055	314.5	100	78	390	.004	1.3	.58					5	
4	1102	318.9	105	82	390	.004	1.3	.59					5	
5	1110	323.3	110	86	390	.004	1.3	.59					5	
6	1117	327.9	115	90	392	.004	1.3	.60					5	
7	1125	331.4	117	92	392	.004	1.3	.60					5	
8	1132	335.8	118	94	392	.004	1.3	.60					5	
STOP	1140	340.482												
		54.808	99.2		390.8		1.3		0.0132					

Moisture Data	Initial	Final	Net	Rinse
Impinger #1	100	101	1	20
Impinger #2	100	101	1	
Impinger(s) #				
Impinger(s) #				
Silica Gel:	200	207	7	
Total Net / Rinse:			7	
Total Sample Volume:			27	

Field Calculations	
Sample Vol., dscf:	
% H_2O:	
MWs:	
MWd:	
Stack Vel, ft/s:	
Flow rate, acfm:	
Flow rate, dscfm:	
% Isokinetics:	

Comments:

000182

C:\Forms\Field\Isok.xls

Isokinetic Sampling Data Sheet (Method 26)

Facility: LLNL M50 **Date:** 8-19-98 **Run #:** 1 **Personnel:** RJB

Facility Information		Equipment Information		Sampling Information	
Location:	Baghouse Outlet	Meter #:	2900	Pbar:	29.7
Port Dia.:	1"	Yd:	.9818	Pstatic:	
Depth:		Pitot #:		% O_2:	
Fitting:		Cp:		% CO_2:	
Length:		ΔH@:		% H_2O:	
Stack Dia:	1.375	Noz. #:		Run Mins:	60
Area:	0.0103	Filter Box #:			
Upstream from disturbance:		D_n:			
Downstream from disturbance:		Filter #:			
		Mag. #:			
		Probe #:			
		Umb. #:			
		Pyrometer #:			

Initial LC: 0 CFM @ ____ "Hg Final LC: 0 CFM @ ____ "Hg Pitot LC: ——

Point	Time	Gas Meter Vol, Ft^3	Meter Temp, °F In	Meter Temp, °F Out	Stack Temp, °F	ΔP	ΔH	Meter ACFM	SQRT ΔP	Temp, °F Probe	Temp, °F Filter	Temp, °F Imp.	Vac, "Hg	Notes
	0915	251.8	75	74										
	0920	261.1	76	74										
	0925	271.2	76	74										
	0930	281.3	77	74										
	0935	290.8	79	75										
	0940	300.4	81	77										
	0945	310.5	82	78										
	0950	320.4	83	78										
	0955	330.3	84	79										
	1000	340.2	84	80										
	1005	350.1	84	81										
	1010	360.0	84	81										
End	1015	370.3												
	liters	118.5	78.8											

Moisture Data	Initial	Final	Net	Rinse
Impinger #1				
Impinger #2				
Impinger(s) #				
Impinger(s) #				
Silica Gel:				
Total Net / Rinse:				
Total Sample Volume:				

Field Calculations	
Sample Vol., dscf:	
% H_2O:	
MWs:	
MWd:	
Stack Vel, ft/s:	
Flow rate, acfm:	
Flow rate, dscfm:	
% Isokinetics:	

Comments: No condensation in line

000183

G:\forms\field\isok.xls

Isokinetic Sampling Data Sheet (Method 26)

Facility: LLNL MSO **Date:** 8/19/98 **Run #:** 2 **Personnel:** RB

Facility Information		Equipment Information		Sampling Information	
Location: Filter Out/Int		Meter #: 2900	Pitot #: —	Pbar:	
Port Dia.:	Depth:	Yd: .9818	Cp: —	Pstatic:	
Fitting:	Length:	ΔH@:	Noz. #: —	% O_2:	
Stack Dia:	Area:	Filter Box #: —	D_n: —	% CO_2:	
Upstream from disturbance:		Filter #: —	Mag. #:	% H_2O:	
Downstream from disturbance:		Probe #: —	Umb. #	Run Mins: 60	
		Pyrometer #: —			

Initial LC: 0 CFM @ °Hg Final LC: CFM @ °Hg Pitot LC:

Point	Time	Gas Meter Vol. Ft³	Meter Temp. °F In	Meter Temp. °F Out	Stack Temp. °F	ΔP	ΔH	Meter ACFM	SQRT ΔP	Temp. °F Probe	Temp. °F Filter	Temp. °F Imp.	Vac. "Hg	Notes
	1025	370.9	82	80										
	1030	380.4	83	81										
	1035	390.2	84	82										
	1040	400.0	84	82										
	1045	410.0	84	82										
	1050	419.9	84	85										
	1055	429.8	85	83										
	1100	439.6	86	83										
	1105	449.4	86	83										
	1110	459.2	86	84										
	1115	469.4	86	84										
	1120	479.3	86	84										
Final	1125	489.2												
		118.3	83.6											

Moisture Data	Initial	Final	Net	Rinse
Impinger #1				
Impinger #2				
Impinger(s) #				
Impinger(s) #				
Silica Gel:				
Total Net / Rinse:				
Total Sample Volume:				

Field Calculations	
Sample Vol., dscf:	
% H_2O:	
MWs:	
MWd:	
Stack Vel, ft/s:	
Flow rate, acfm:	
Flow rate, dsfm:	
% Isokinetics:	

Comments:

000184

Isokinetic Sampling Data Sheet (Method 24)

Facility: LLNL M50 **Date:** 8-9-98 **Run #:** 3 **Personnel:**

Facility Information		Equipment Information		Sampling Information	
Location: Filter outlet		Meter #: 2700	Pitot #:	Pbar:	
Port Dia.:	Depth:	Yd: 0.9818	Cp:	Pstatic:	
Fitting:	Length:	ΔH@:	Noz. #:	% O_2:	
Stack Dia:	Area:	Filter Box #:	D_n:	% CO_2:	
Upstream from disturbance:		Filter #:	Mag. #:	% H_2O:	
Downstream from disturbance:		Probe #:	Umb. #	Run Mins: 60	
		Pyrometer #:			

Initial LC: 0 CFM @ 1pm °Hg Final LC: CFM @ °Hg Pitot LC:

Point	Time	Gas Meter Vol, Ft^3	Meter Temp, °F In	Meter Temp, °F Out	Stack Temp, °F	ΔP	ΔH	Meter ACFM	SQRT ΔP	Temp, °F Probe	Temp, °F Filter	Temp, °F Imp.	Vac., "Hg	Notes
	1131	489.8	84	83										
	1136	499.4	85	83										
	1141	509.2	86	83										
	1146	519.1	86	83										
	1151	529.0	86	83										
	1156	538.8	86	84										
	1201	548.6	86	84										
	1206	558.5	86	84										
	1211	568.4	86	84										
	1216	578.3	87	84										
	1221	588.3	87	84										
	1226	598.1	87	84										
End	1231	607.9												
		118.1	84.8											

Moisture Data	Initial	Final	Net	Rinse
Impinger #1				
Impinger #2				
Impinger(s) #				
Impinger(s) #				
Silica Gel:				
Total Net / Rinse:				
Total Sample Volume:				

Field Calculations	
Sample Vol., dscf:	
% H_2O:	
MWs:	
MWd:	
Stack Vel. ft/s:	
Flow rate, acfm:	
Flow rate, dscfm:	
% Isokinetics:	

Comments:

BEST ENVIRONMENTAL, INC. San Leandro, CA (510)278-4011

Isokinetic Sampling Data Sheet (Method HCl/)

Facility: **Date:** 8/26/98 **Run #:** 1,2,3 **Personnel:** OC

Facility Information		Equipment Information		Sampling Information	
Location: Filter outlet		Meter #: 8314	Pitot #:	Pbar:	
Port Dia.:	Depth:	Yd:	Cp:	Pstatic:	
Fitting:	Length:	ΔH@:	Noz. #:	% O_2:	
Stack Dia:	Area:	Filter Box #:	D_n:	% CO_2:	
Upstream from disturbance: 3		Filter #:	Mag. #:	% H_2O:	
Downstream from disturbance: 2		Probe #:	Umb. #	Run Mins	
		Pyrometer #:			

Initial LC: .001/.001/.002 CFM @ 15/15/15 "Hg Final LC: .001/.001/.001 CFM @ 15/15/15 "Hg Pitot LC:

Point	Time	Gas Meter Vol. Ft³	Meter Temp. °F In	Meter Temp. °F Out	Stack Temp. °F	ΔP	ΔH	Meter ACFM	SQRT ΔP	Temp. °F Probe	Temp. °F Filter	Temp. °F Imp.	Vac., "Hg	Notes
	1519	2.496.0	78	78			~~2.0~~							
	1524		80	78			.1							
	1529		80	79			.1							
	1534		80	79			.1							
	1539		81	79										
	1544		81	79										
	1549		81	79										
	1554		81	79										
	1559		81	79										
	1604	2582.0	81	79										
	1609		81	79										
	1614		81	79										
	1619	2620.7	[80.0]											
		[174.7]												
		~~2620.7~~												
	1637	2623.0	80	79			1808	27700	83/83					
	1647		80	79			1818		83/83					
	57		81	80										
	07		82	82			1838	28300	83/83					
	17		82	82			1848							
	27		83	83			1858		84/84					
	1737		84	84			1908		84/84					
	1747	27680	84	84				28908						
		[145.0]	[81.8]					[120.8]	[83.0]					

Moisture Data	Initial	Final	Net	Rinse
Impinger #1				
Impinger #2				
Impinger(s) #				
Impinger(s) #				
Silica Gel:				
Total Net / Rinse:				
Total Sample Volume:				

Field Calculations	
Sample Vol., dscf:	
% H_2O:	
MWs:	
MWd:	
Stack Vel, ft/s:	
Flow rate, acfm:	
Flow rate, dscfm:	
% Isokinetics:	

Comments:

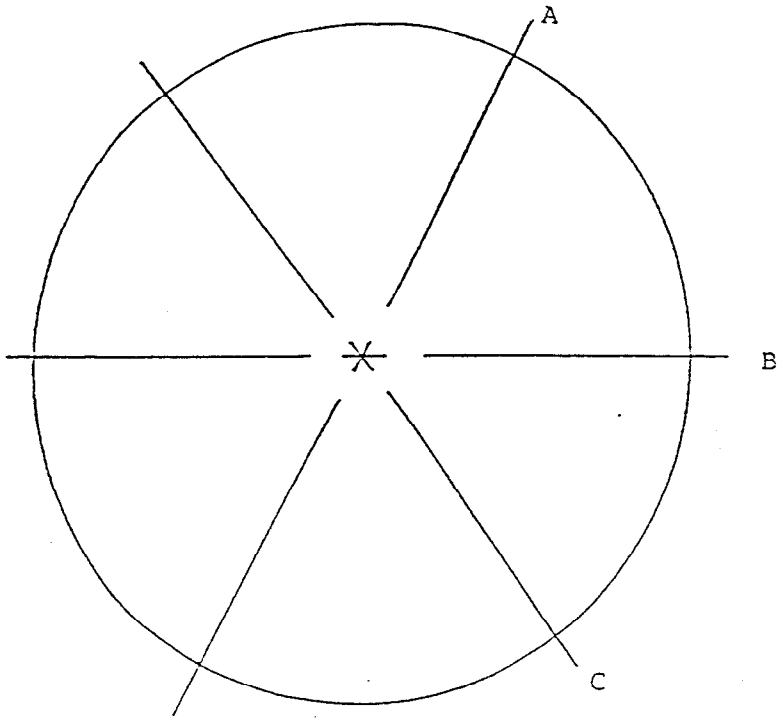
000196

G:\forms\field\isk1.xls

APPENDIX D
EQUIPMENT CALIBRATION RECORDS

a1

BEST ENVIRONMENTAL, INC.
Nozzle Calibration



Diameter Dimension
0.378
0.378
0.378
Average
0.378
Range
.000

Nozzle type:
- Glass: 6A M5
- Quartz:
- Stainless Steel:
- Other:

Date: 1-16-98

Recorded By: B B Gallup

Next Cal. due: 1-16-99

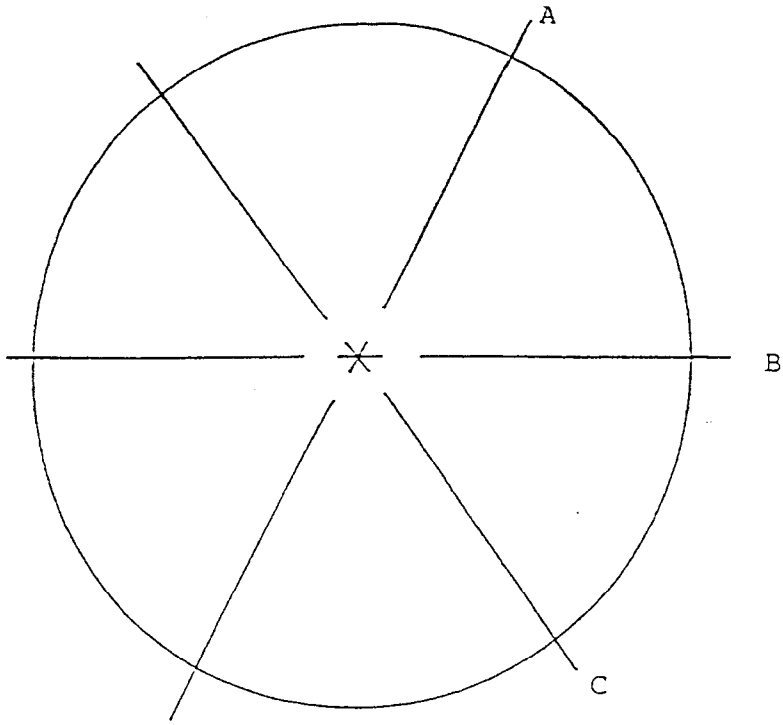
Reference Method: EPA 5 (section 5.1)

Acceptance Limits: < 0.004" range of 3 measurements

Calibration Frequency: 12 Months

AAMSaccal

BEST ENVIRONMENTAL, INC.
Nozzle Calibration



Diameter Dimension
0.324
0.327
0.326
Average
0.326
Range
0.003

Nozzle type:	
	Glass:
	Quartz: Q-5B
	Stainless Steel:
	Other:

Date: 1-15-98

Recorded By: BrBGallagh

Next Cal. due: 1-15-99

Reference Method: EPA 5 (section 5.1)

Acceptance Limit: < 0.004" range of 3 measurements

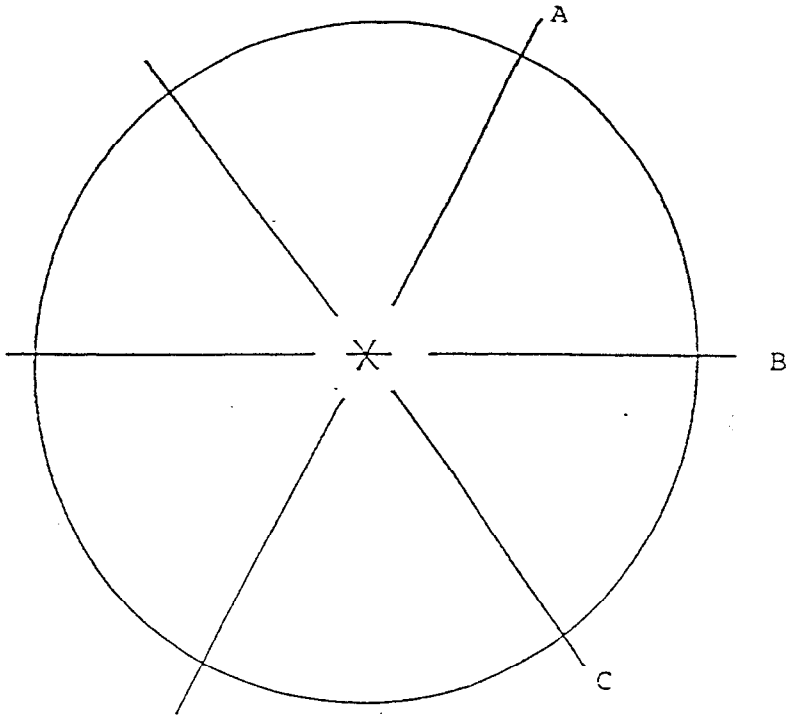
Calibration Frequency: 12 Months

AAMSnozzl

00019

a2

BEST ENVIRONMENTAL, INC.
Nozzle Calibration



Diameter Dimension
0.308
0.309
0.310
Average
0.309
Range
0.002

Nozzle type:

Glass: 5-E MS
Quartz:
Stainless Steel:
Other:

Date: 1-16-98

Recorded By: [signature]

Next Cal. due: 1-16-99

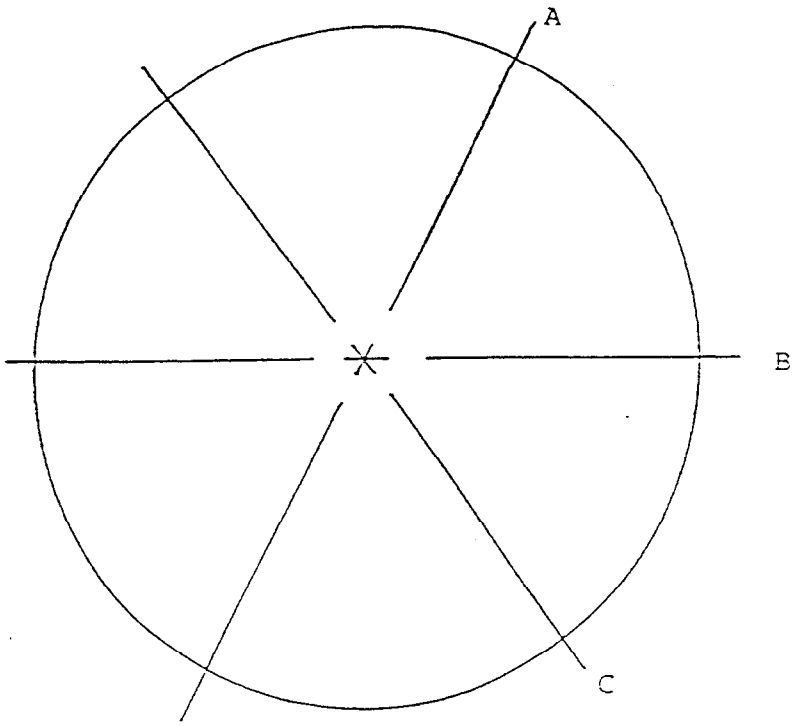
Reference Method: EPA 5 (section 5.1)

Acceptance Limit: < 0.004" range of 3 measurements

Calibration Frequency: 12 Months

AAMSuccess

BEST ENVIRONMENTAL, INC.
Nozzle Calibration



Diameter Dimension
0.305
0.304
0.304
Average
0.304
Range
.001

Nozzle type:
- Glass: 5B MS
- Quartz:
- Stainless Steel:
- Other:

Date: 1-16-98

Recorded By: B B Gallagher

Next Cal. due: 1-16-99

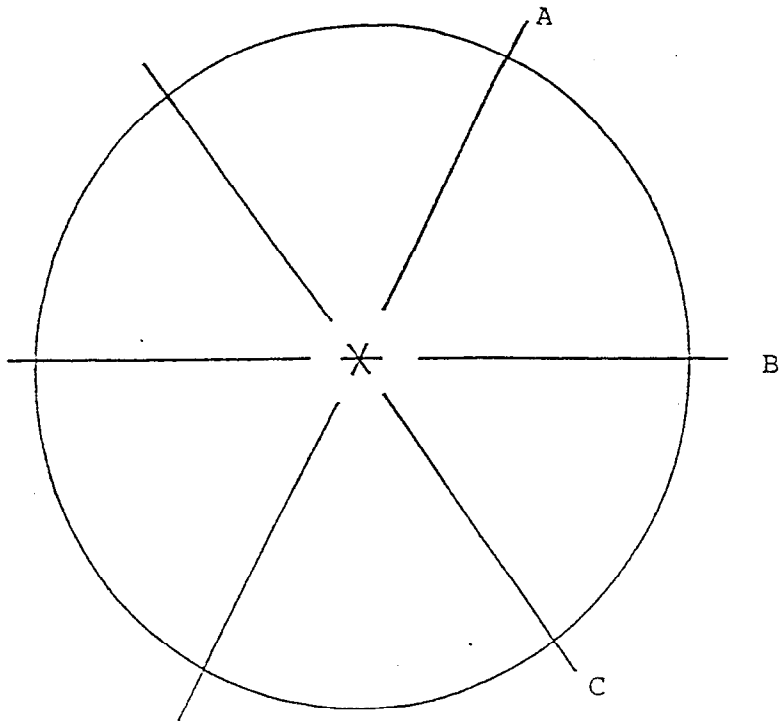
Reference Method: EPA 5 (section 5.1)

Acceptance Limits: < 0.004" range of 3 measurements

Calibration Frequency: 12 Months

AAMSeries1

BEST ENVIRONMENTAL, INC.
Nozzle Calibration



Diameter Dimension
.749
.753
.753
Average
.752
Range
.004

Nozzle type:

Glass:
Quartz:
Stainless Steel: 41
Other:

Date: 1/27/98

Recorded By: M. Wiley

Next Cal. due: 1/27/99

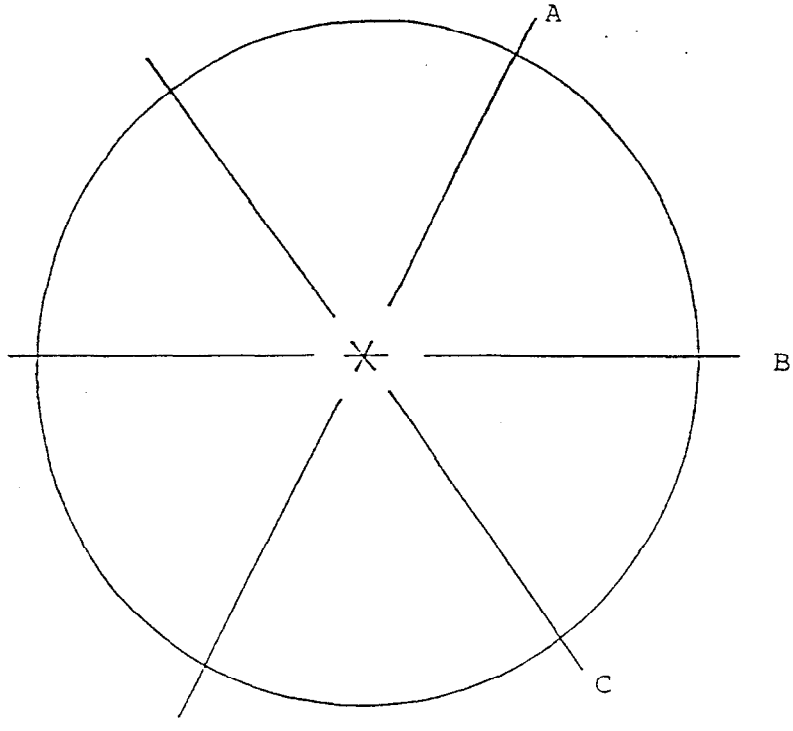
Reference Method: EPA 5 (section 5.1)

Acceptance Limit: < 0.004" range of 3 measurements

Calibration Frequency: 12 Months

AAMSnozzcal

BEST ENVIRONMENTAL, INC.
Nozzle Calibration



Diameter Dimension
0.970
0.971
0.972
Average
0.971
Range
0.002

Nozzle type:	
	Glass:
	Quartz:
	Stainless Steel: 1
	Other:

Date: 1/27/98

Recorded By: M. Wiley

Next Cal. due: 1/27/99

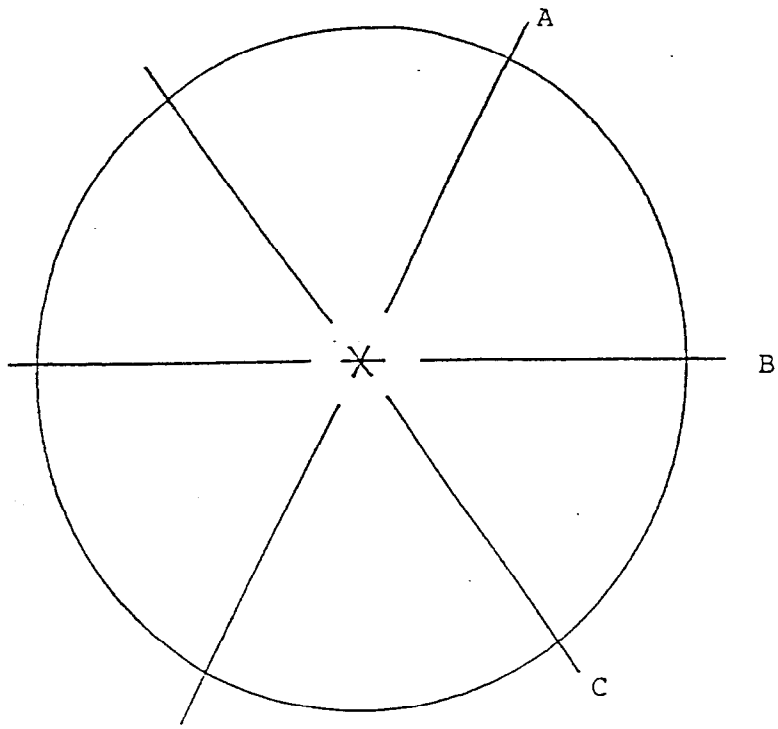
Reference Method: EPA 5 (section 5.1)

Acceptance Limit: < 0.004" range of 3 measurements

Calibration Frequency: 12 Months

AAM Section

BEST ENVIRONMENTAL, INC.
Nozzle Calibration



Diameter Dimension
0.751
0.752
0.750
Average
0.751
Range
0.002

Nozzle type:	
	Glass:
	Quartz:
	Stainless Steel: 40
	Other:

Date: 1/26/98

Recorded By: M. Wiley

Next Cal. due: 1/26/99

Reference Method: EPA 5 (section 5.1)

Acceptance Limit: < 0.004" range of 3 measurements

Calibration Frequency: 12 Months

A-AM5nozcal

BEST ENVIRONMENTAL, INC. San Leandro, CA (510)278-4011

METER BOX FULL TEST CALIBRATION

Meter #: L.S.I. #1
Meter Orifice ID: fixed box orifice
Standard Meter: Wet Gas Meter
Test Vacuum "Hg: n/a
Bar. Pressure (Pb): 29.93
Leak Checked: Yes @ 18"Hg.

Date: 09-10-97.
Operator: Bob Gallagher
Signature B.G.
QAQC Officer: C.T.

	Yd	ΔH@
Current	1.0039	2.196
Previous	0.9886	2.091

ΔH	ΔP	Yds	Standard Meter Gas Volume (ft³) Initial	Final	(Vds) Net	Meter Box Gas Volume (ft³) Initial	Final	(Vd) Net	Std. Meter Temp. (T_{ds}) Avg.	Meter Box Temperature (T_i) Inlet Init.	End	(T_e) Outlet Init.	End	(T_d) Avg.	Time (Min.) Ø	Q	Yd	ΔH@
0.50	0.090	1.000	0.000	9.200	9.200	997.738	1007.115	9.377	76.0	92	100	82	84	89.5	25.38	0.357	1.0044	2.132
0.50	-0.100	1.000	9.200	15.000	5.800	7.115	13.044	5.929	76.0	95	98	83	84	90.0	16.05	0.356	1.0023	2.144
0.50	-0.100	1.000	15.000	21.250	6.250	13.044	19.449	6.405	76.0	98	102	84	86	92.5	17.32	0.356	1.0044	2.144
1.50	-0.125	1.000	0.000	10.000	10.000	19.792	29.982	10.190	77.0	99	104	84	85	93.0	15.98	0.615	1.0066	2.149
1.50	-0.120	1.000	10.000	22.250	12.250	29.982	42.527	12.545	77.0	103	104	84	85	94.0	19.75	0.610	1.0034	2.187
1.50	-0.125	1.000	22.250	32.250	10.000	42.527	52.815	10.288	77.0	103	106	85	87	95.3	16.18	0.608	1.0010	2.197
3.00	-0.155	1.000	0.000	10.000	10.000	53.349	63.567	10.218	78.0	105	105	87	88	96.3	11.62	0.845	1.0041	2.268
3.00	-0.150	1.000	10.000	20.000	10.000	63.567	73.806	10.239	78.0	104	108	88	89	97.3	11.62	0.845	1.0038	2.264
3.00	-0.155	1.000	20.000	30.000	10.000	73.806	84.053	10.247	78.0	106	110	88	90	98.5	11.66	0.842	1.0053	2.278

Comments: This is the Calib. Cert.

Variables:

- Q = Flow rate (cfm)
- ΔH = Orifice pressure differential (in. H_2O)
- ΔP = Inlet pressure differential standard meter (in. H_2O)
- Yds = Standard meter correction factor (Unitless)
- Yd = Meter box correction factor (Unitless)
- ΔH@ = Orifice pressure differential that gives 0.75 DSCFM of air at 68°F and 29.92 in. Hg (in. H_2O)

$$Yd = (Yds)\left(\frac{Vds}{Vd}\right)\left(\frac{Td + 460}{Tds + 460}\right)\left(\frac{Pb + \Delta P/13.6}{Pb + \Delta H/13.6}\right)$$

$$\Delta H@ = \frac{0.0317 \times \Delta H}{Pb(T_e + 460)}\left[\frac{(Tds + 460)\theta}{Vds \times Yds}\right]^2$$

$$Q = \frac{17.64 \times Vds \times Pb}{(Tds + 460)\theta}$$

1 Yd Tolerance (Yd$_{max}$-Yd) ±0.02 ref Fig 5.6 in EPA method 5

BEST ENVIRONMENTAL, INC.

San Leandro, CA (510)278-4011

METER BOX FULL TEST CALIBRATION

Meter #: L.S.I.#1
Meter Orifice ID: boxes orifice
Standard Meter: Wet Gas Meter
Test Vacuum "Hg: 0"Hg
Bar. Pressure (Pb): 29.79
Leak Checked: Yes at 17"Hg

Date: 09-11-98.
Operator: Bob Gallagher
Signature BG
QAQC Officer: CT

	Yd	ΔH@
Current	0.9894	2.212
Previous	1.0039	2.196

ΔH	ΔP	Yds	Standard Meter Gas Volume (ft³) Initial	Final	(Vds) Net	Meter Box Gas Volume (ft³) Initial	Final	(Vd) Net	Std. Meter Temp. (T_{ds}) Avg.	Meter Box Temperature (T_i) Inlet Infl.	End	(T_o) Outlet Infl.	End	(T_d) Avg.	Time (Min.) Ø	Q	Yd	ΔH@
0.50	-0.085	1.000	10.000	16.650	6.650	532.406	539.353	6.947	82.0	110	110	91	94	101.3	18.03	0.358	0.9898	2.080
0.50	-0.090	1.000	16.650	23.150	6.500	539.353	546.171	6.818	83.0	110	115	94	96	103.8	17.68	0.356	0.9884	2.091
0.50	-0.085	1.000	23.150	31.000	7.850	546.171	554.413	8.242	83.0	112	116	94	96	104.5	21.30	0.357	0.9887	2.081
1.50	-0.115	1.000	0.000	16.000	16.000	554.587	571.387	16.800	84.0	114	115	94	96	104.8	26.00	0.595	0.9848	2.248
1.50	-0.120	1.000	16.000	29.773	13.773	571.387	585.791	14.404	84.0	115	115	96	96	105.5	22.22	0.599	0.9900	2.211
1.50	-0.120	1.000	29.773	42.195	12.422	585.791	598.779	12.988	84.0	112	116	96	98	105.5	20.07	0.598	0.9903	2.213
3.00	-0.140	1.000	0.000	19.450	19.450	599.047	619.283	20.236	84.0	111	116	98	99	106.0	22.60	0.832	0.9923	2.284
3.00	-0.145	1.000	19.450	33.250	13.800	619.283	633.675	14.392	85.0	116	117	98	99	107.5	16.15	0.824	0.9908	2.325
3.00	-0.140	1.000	33.250	47.070	13.820	633.675	648.102	14.427	85.0	115	117	98	99	107.3	16.36	0.815	0.9894	2.379

Comments: This is the Calib. Cert.

Variables:

Q = Flow rate (cfm)
ΔH = Orifice pressure differential (in. H_2O)
ΔP = Inlet pressure differential standard meter (in. H_2O)
Yds = Standard meter correction factor (Unitless)
Yd = Meter box correction factor (Unitless)
ΔH@ = Orifice pressure differential that gives 0.75 DSCFM of air at 68°F and 29.92 in. Hg (in. H_2O)

$$Yd = (Yds)\left(\frac{Vds}{Vd}\right)\left(\frac{Td + 460}{Tds + 460}\right)\left(\frac{Pb + \Delta P/13.6}{Pb + \Delta H/13.6}\right)$$

$$\Delta H@ = \frac{0.0317 \times \Delta H}{Pb(T_o + 460)}\left[\frac{(Tds + 460)\theta}{Vds \times Yds}\right]^2$$

$$Q = \frac{17.64 \times Vds \times Pb}{(Tds + 460)\theta}$$

1. Yd Tolerance: $(Yd_{Avg} - Yd) \pm 0.02$ ref. Fig 5.6 in EPA method 5
2. ΔH@ Tolerance: $(\Delta H@_{Avg} - \Delta H@) \pm 0.20$ ref. fig 5.6 in EPA method 5.

g:\cals\metercal\master1

Spring Type Thermometer Calibration

Calibrated By: B. Bellah

Date Calibrated: 5-8-98

Calibration Due: 11-8-98

LSI #1

Thermometer ID	Reference Thermometer Temp. (°F)	Test Thermocouple Temp (°F)	Temp. Difference	% Difference	Notes
LSI #1					
Meter in 1BA	33°F	34°F	+1°F		
1BA	72°F	73°F	+1°F		Pass
1BA	112°F	112°F	0		
Meter on 1B8	34°F	34°F	0		
1B8	72°F	72°F	0		Pass
1B8	111°F	110°F	-1°F		

NIST Pyrometer: Omega HH22 T134449 Nist cert 9-15-97

ASTM Thermometer: 61132-006

Comments: Thermocouple Probe # 91-006

Reference Thermometer: ASTM mercury in glass.
Method Reference: EPA QA Handbook Vol. III: Stationary Source Specific Methods, sec. 3.5.2.2
Tolerance Limits: ±5.4 °F at ambient temperature and in hot water bath.

000197

Pressure & Vacuum Gauge Calibrations

Calibration Date: 3-10-98
Calibrated By: BB Gallagher
Gauge Location: LSI #1

Gauge Number: LSI #1 ΔP
ID Number: R8909056931
Calibration Frequency: Semi Annual 9-10-98

Magnehelic: ✓ Vacuum:_____ Pressure:_____

Gauge Range	Manometer or Slack Tube	Gauge Reading	Difference %	Notes Pass / Fail
0 TO 3"				
	+ .75"	+ .75"	0	Pass
	+ 1.81"	+ 1.82"	+ .552%	Pass
	+ 2.65"	+ 2.70"	+ 1.887%	Pass
	- .75"	- .75"	0	Pass
	- 1.68"	- 1.70"	1.190%	Pass
	- 2.77"	- 2.80"	1.083%	Pass
Reference Equipment Used (ID#):				
% Difference = (Reference - Gauge) / Gauge Range				

COMMENTS: USED Dwyer 0 TO 5" INCLINE MANOMETER AS STANDARD.

Vacuum Gauges & Pressure Gauges Acceptance Limits: = 3% of Range

Pressure & Vacuum Gauge Calibrations

Calibration Date: 3-10-98
Calibrated By: [illegible]
Gauge Location: LSI #1

Gauge Number: LSI #1 ΔH
ID Number: R9518816S414
Calibration Frequency: Semi Annual 9-10 98

Magnehelic: ✓ Vacuum: ____ Pressure: ____

Gauge Range	Manometer or Slack Tube	Gauge Reading	Difference %	Notes Pass / Fail
0 TO 5"				
	+ 1.3"	+ 1.3"	0	Pass
	+ 3.0"	+ 3.05"	+ 0.167%	Pass
	+ 4.47"	+ 4.50"	+ 0.167%	Pass
	- 1.0"	- 1.0"	0	Pass
	- 2.6"	- 2.6"	0	Pass
	- 4.475"	- 4.55"	1.676%	Pass
Reference Equipment Used (ID#):				
% Difference = (Reference - Gauge) / Gauge Range				

COMMENTS: Used Dwyer 0 to 5" Incline Manometer As STD.

Vacuum Gauges & Pressure Gauges Acceptance Limits: = 3% of Range

g:\forms\calform.xls - 12/5/97

000190

97

BEST ENVIRONMENTAL, INC.

METER BOX FULL TEST CALIBRATION

Meter #: L.S.I#2
Meter Orifice ID: boxes orifice
Date: 09-15-97. Standard Meter: Wet Gas Meter Current
Operator: Bob Gallagher Test Vacuum "Hg: 0"Hg
Signature BG Bar. Pressure (Pb): 29.83 Previous
QAQC Officer: CT Leak Checked: Yes at 17"Hg

			Standard Meter Gas Volume (ft³)			Meter Box Gas Volume (ft³)			Std. Meter Temp.	Meter Box Temperature					Time (Min.)
ΔH	ΔP	Yds	Initial	Final	(Vds) Net	Initial	Final	(Vd) Net	(T_{da}) Avg.	(T_i) Inlet Init.	Inlet End	(T_o) Outlet Init.	Outlet End	(T_d) Avg.	Ø
0.50	-0.110	1.000	0.000	5.260	5.260	862.522	867.803	5.281	80.0	87	87	82	82	84.5	13.48
0.50	-0.110	1.000	5.260	10.520	5.260	867.803	873.087	5.284	80.0	87	87	82	82	84.5	13.50
0.50	-0.115	1.000	10.520	17.350	6.830	873.087	879.947	6.860	80.0	87	87	82	82	84.5	17.55
1.50	-0.140	1.000	0.000	10.100	10.100	880.074	890.102	10.028	80.0	90	90	83	83	86.5	14.96
1.50	-0.145	1.000	10.100	20.200	10.100	890.102	900.140	10.038	80.0	90	91	83	83	86.8	14.96
1.50	-0.140	1.000	20.200	30.250	10.050	900.140	910.208	10.068	81.0	91	94	83	84	88.0	14.90
3.00	-0.165	1.000	0.000	10.100	10.100	911.750	921.830	10.080	81.0	96	101	84	85	91.5	10.50
3.00	-0.160	1.000	10.100	20.250	10.150	921.830	931.995	10.165	81.0	101	102	85	85	93.3	10.52
3.00	-0.165	1.000	20.250	37.300	17.050	931.995	949.131	17.136	81.0	101	102	84	85	93.0	17.68

Comments: This is the Calib. Cert.

Variables:

Q = Flow rate (cfm)
ΔH = Orifice pressure differential (in. H_2O)
ΔP = Inlet pressure differential standard meter (in. H_2O)
Yds = Standard meter correction factor (Unitless)
Yd = Meter box correction factor (Unitless)
ΔH@ = Orifice pressure differential that gives 0.75 DSCFM of air at 68°F and 29.92 in. Hg (in. H_2O)

$$Yd = (Yds)\left(\frac{Vds}{Vd}\right)\left(\frac{Td + 460}{Tds + 460}\right)\left(\frac{Pb + \Delta P/13}{Pb + \Delta H/13}\right.$$

$$\Delta H@ = \frac{0.0317 \times \Delta H}{Pb(T_a + 460)}\left[\frac{(Tds + 460)\theta}{Vds \times Yds}\right]^2$$

$$Q = \frac{17.64 \times Vds \times Pb}{(Tds + 460)\theta}$$

1 Yd Tolerance (Yd$_{max}$-Yd) ≤ 0.02 ref Fig 5 6 in EPA method 5

2 ΔH@ Tolerance (ΔH@$_{max}$-ΔH@) ≤ 0.20 ref Fig 5 6 in EPA method 5.

BEST ENVIRONMENTAL, INC. San Leandro, CA (510)278-4011

METER BOX FULL TEST CALIBRATION

Meter #: L.S.I.#2
Meter Orifice ID: boxes orifice
Standard Meter: Wet Gas Meter
Test Vacuum "Hg: 0"Hg
Bar. Pressure (Pb): 30.01
Leak Checked: Yes at 17"Hg

Date: 09-23-98.
Operator: Bob Gallagher
Signature BG
QAQC Officer: CT

	Yd	ΔH@
Current	0.9840	1.805
Previous	1.0089	1.869

ΔH	ΔP	Yds	Standard Meter Gas Volume (ft³)			Meter Box Gas Volume (ft³)			Std. Meter Temp.	Meter Box Temperature					Time (Min.)			
			Initial	Final	(Vds) Net	Initial	Final	(Vd) Net	(T_{ds}) Avg.	(T_i) Inlet Init.	(T_i) Inlet End	(T_o) Outlet Init.	(T_o) Outlet End	(T_d) Avg.	Ø	Q	Yd	ΔH@
0.50	-0.085	1.000	0.000	7.000	7.000	393.248	400.400	7.152	70.0	78	78	72	72	75.0	16.95	0.413	0.9866	1.635
0.50	-0.090	1.000	7.000	12.100	5.100	400.400	405.627	5.227	70.0	76	78	72	73	74.8	12.65	0.403	0.9830	1.714
0.50	-0.090	1.000	12.100	19.062	6.962	405.627	412.776	7.149	71.0	76	78	72	74	75.0	17.33	0.401	0.9798	1.731
1.50	-0.125	1.000	0.000	14.400	14.400	430.116	444.932	14.816	72.0	80	87	75	77	79.8	21.52	0.666	0.9822	1.869
1.50	-0.115	1.000	0.000	17.530	17.530	461.758	479.769	18.011	75.0	78	90	78	80	81.5	26.30	0.660	0.9812	1.894
1.50	-0.120	1.000	17.530	29.751	12.221	479.769	492.357	12.588	75.0	86	90	76	80	83.0	18.40	0.657	0.9815	1.911
3.00	-0.145	1.000	0.000	16.655	16.655	492.590	509.640	17.050	75.0	90	93	79	80	85.5	17.40	0.947	0.9884	1.835
3.00	-0.140	1.000	16.655	26.895	10.240	509.640	520.134	10.494	75.0	91	92	80	81	86.0	10.70	0.947	0.9883	1.832
3.00	-0.140	1.000	26.895	37.497	10.602	520.134	531.035	10.901	75.0	91	92	81	81	86.3	11.07	0.948	0.9854	1.828

Comments: This is the Calib. Cert.

Variables:
- Q = Flow rate (cfm)
- ΔH = Orifice pressure differential (in. H_2O)
- ΔP = Inlet pressure differential standard meter (in. H_2O)
- Yds = Standard meter correction factor (Unitless)
- Yd = Meter box correction factor (Unitless)
- $\Delta H@$ = Orifice pressure differential that gives 0.75 DSCFM of air at 68°F and 29.92 in. Hg (in. H_2O)

$$Yd = (Yds)\left(\frac{Vds}{Vd}\right)\left(\frac{Td+460}{Tds+460}\right)\left(\frac{Pb+\Delta P/13.6}{Pb+\Delta H/13.6}\right)$$

$$\Delta H@ = \frac{0.0317\times\Delta H}{Pb(T_o+460)}\left[\frac{(Tds+460)\theta}{Vds\times Yds}\right]^2$$

$$Q = \frac{17.64\times Vds\times Pb}{(Tds+460)\theta}$$

1 Yd Tolerance $(Yd_{max}-Yd)\pm 0.02$ ref Fig 5 6 in EPA method 5

2 ΔHoo Tolerance $(\Delta H@_{max}-\Delta H@)\pm 0.20$ ref fig 5 6 in EPA method 5

g:\cals\metercal\master1

Pressure & Vacuum Gauge Calibrations

Calibration Date: 9-2-98
Calibrated By: Ruiz Romando
Gauge Location: LSI #2

ID Number: LSI #2 Δ P
Gauge Type: R1031GVR115
Calibration Frequency: SEMI-ANNUAL 3-2-99

Magnehelic: ✓ Vacuum: _____ Pressure: _____

Gauge Range	Manometer or Slack Tube	Gauge Reading	Difference %	Notes Pass / Fail
R1031GVR115	+1.85	+1.82	1.648 %	PASS
0-5"	+3.05	+3.10	1.613 %	PASS
	+4.45	+4.55	2.198 %	PASS
	-1.75	-1.72	1.744 %	PASS
	-3.08	-3.10	.645 %	PASS
	-4.50	-4.60	2.174 %	PASS
Reference Equipment Used (ID#):				
% Difference = (Reference - Gauge) / Gauge Range				

COMMENTS: USED 0-10 DWYER INCLINE MANOMETER AS STD.

Vacuum Gauges & Pressure Gauges Acceptance Limits: ± 3% of Range

Type K Thermocouple Calibration

Pitot #: _____
Probe #: _____
Probe Type/Length: _____
Meter # LSI #2
Heater Box # _____
Other: _____

Calibration Date	Thermocouple ID	Reference Temp. (°F)	Test T/C Temp. (°F)	Temp. Difference	% Difference	Initials	Notes Pass/Fail
9-15-97							
KEADOUT	#1 PROBE	400°F	399.7°F	-.3°F	-0.075%	BG	PASS
K Type	#2 OVEN	200°F	201.6°F	+1.6°F	+.80%	BG	"
"	#3 STACK	300°F	299.8°F	-.2°F	-.067%	BG	"
	#4 XTRA	100°F	99.2°F	-.8°F	-.80%	BG	"
	#5 XTRA	500°F	500.2°F	+.2°F	+.04%	BG	"

NIST Pyrometer: T134449

NIST Thermocouple: 912006

Comments: ALSO USED Omega Thermocouple Simulator S/N 912
Model # CL300-1200C . K Type.

Reference Thermometer: ASTM Mercury in Glass.
Method Reference: Code of Federal Regulations, 40 CFR 60, Appendix A, Method 2, Revised as of July 1, 1992.
Tolerance Limits: +/-4.0 °F For Temp <400°.
Tolerance Limits: +/-1.5% For Temp >400°.

Spring Type Thermometer Calibration

Calibrated By: Darren M. Lane

Date Calibrated: 4-14-97

Calibration Due: 10-14-97

LSI #2

Thermometer ID	Reference Thermometer Temp. (°F)	Test Thermocouple Temp (°F)	Temp. Difference	% Difference	Notes
LSI #2					
meter IN #16B	34°F	35°F	+1°F	2.9%	
	71°F	71°F	0	0	
	104°F	100°F	-4°F	3.8%	
meter out #16A	35°F	36°F	+1°F	2.9%	
	72°F	71°F	-1°F	1.4%	
	100°F	98°F	-2°F	2.0%	

NIST Pyrometer: T134449

ASTM Thermometer: 61132-006

Comments: Passed

Reference Thermometer: ASTM mercury in glass.
Method Reference: EPA QA Handbook Vol. III: Stationary Source Specific Methods, sect. 3.5.2.2
Tolerance Limits: ±5.4 °F at ambient temperature and in hot water bath.

BEST ENVIRONMENTAL, INC.

San Leandro, CA (510)278-4011

METER BOX FULL TEST CALIBRATION

Meter #: A.S.I. 8,

Meter Orifice ID: boxes orifice

Date: 02-05-98,

Standard Meter: Wet Gas Meter

Operator: Bob Gallagher

Test Vacuum "Hg: 0"Hg

Signature BG

Bar. Pressure (Pb): 29.84

QAQC Officer: CT

Leak Checked: Yes at 17"Hg

	Yd@	ΔH@
Current	0.9593	1.684
Previous	0.9903	1.590

ΔH	ΔP	Yds	Standard Meter Gas Volume (ft³)			Meter Box Gas Volume (ft³)			Std. Meter Temp.	Meter Box Temperature					Time (Min.)			
			Initial	Final	(Vds) Net	Initial	Final	(Vd) Net	(T_m) Avg.	(T_i) Inlet Init.	Inlet End	(T_o) Outlet Init.	Outlet End	(T_d) Avg.	Ø	Q	Yd	ΔH@
0.50	-0.095	1.000	0.000	6.550	6.550	672.487	679.432	6.945	56.0	64	69	56	63	63.0	16.05	0.416	0.9545	1.635
0.50	-0.090	1.000	6.550	18.345	11.795	679.432	692.146	12.714	56.0	69	73	63	70	68.8	28.97	0.415	0.9493	1.620
0.50	-0.095	1.000	18.345	26.300	7.955	692.146	700.783	8.637	57.0	80	80	71	71	75.5	19.52	0.415	0.9526	1.610
1.50	-0.115	1.000	0.000	17.400	17.400	701.406	720.328	18.922	57.0	79	88	71	75	78.3	25.68	0.690	0.9536	1.741
1.50	-0.110	1.000	17.400	33.305	15.905	720.328	737.708	17.380	57.0	86	85	75	75	80.3	23.47	0.690	0.9525	1.734
1.50	-0.115	1.000	33.305	55.710	22.405	737.708	762.223	24.515	57.0	85	84	75	76	80.0	33.00	0.692	0.9508	1.725
3.00	-0.150	1.000	0.000	19.595	19.595	537.089	557.822	20.733	58.0	81	83	72	75	77.8	20.16	0.988	0.9736	1.697
3.00	-0.150	1.000	19.595	29.700	10.105	557.822	568.572	10.750	58.0	83	91	75	78	81.8	10.42	0.986	0.9755	1.695
3.00	-0.150	1.000	29.700	69.000	39.300	568.572	610.642	42.070	59.0	89	89	77	80	83.8	40.63	0.983	0.9712	1.704

Comments: This is the Calibration Cert.

Variables:

Q = Flow rate (cfm)

ΔH = Orifice pressure differential (in. H_2O)

ΔP = Inlet pressure differential standard meter (in. H_2O)

Yds = Standard meter correction factor (Unitless)

Yd = Meter box correction factor (Unitless)

ΔH@ = Orifice pressure differential that gives 0.75 DSCFM of air at 68°F and 29.92 in. Hg (in. H_2O)

$$Yd = (Yds)\left(\frac{Vds}{Vd}\right)\left(\frac{Td+460}{Tds+460}\right)\left(\frac{Pb+\Delta P/13.6}{Pb+\Delta H/13.6}\right)$$

$$\Delta H@ = \frac{0.0317\times\Delta H}{Pb(T_o+460)}\left[\frac{(Tds+460)\theta}{Vds\times Yds}\right]^2$$

$$Q = \frac{17.64\times Vds\times Pb}{(Tds+460)\theta}$$

1 - 2% Tolerance (Yds, Yd) 0.92 ref. Fig 5.6 in EPA method 5

Type K Thermocouple Calibration

Pitot #: _____ Meter # ASI #8

Probe #: _____ Heater Box # _____

Probe Type: _____ Other: T/Couple READOUT KTYPE

Calibration Date	Thermocouple ID	Reference Temp. (°F)	Test T/C Temp. (°F)	Temp. Difference <400 °F	% Difference >400 °F	Notes Pass / Fail
10-7-98						
	STACK	600.0°F	602 °F	+2 °F	.333%	PASSES
	PROBE	300 °F	300 °F	0		"
	OVEN	300°F	300°F	0		PASSES
	AUX	200°F	201°F	+1 °F		"
	Meter in	63	63	0		"
	Meter out	63	64	+1 °F		"

NIST Pyrometer: T134449 Calibrated By: BoB Gallagher

NIST Thermocouple: 910006 Calibration Frequency: 6 Months 2-7-98

ASTM Mercury in Glass Thermometer #: _____

Comments: ALSO USED K type thermocouple SIMULATOR. OMEGA model 912 S/N CL 3002100F

Method Reference: Code of Federal Regulations, 40 CFR 60, Appendix A, Method 2, Revised as of July 1, 1992.

Tolerance Limits: +/-4.0 °F For Temp <400°F.

Tolerance Limits: +/-1.5% For Temp >400°F.

BEST ENVIRONMENTAL, INC. San Leandro, CA (510)278-4011

METER BOX FULL TEST CALIBRATION

Meter #: 2400lf
Meter Orifice ID: Calib.#1 13/64
Standard Meter: Wet Gas Meter
Test Vacuum "Hg: n/a
Bar. Pressure (Pb): 30.04
Leak Checked: Yes

Date: 4/1/97
Operator: Michael J. Wiley
Signature
QA/QC Officer:

	Yd	ΔH@
Current	0.9818	
Previous	0.9622	

			Standard Meter Gas Volume (ft³)			Meter Box Gas Volume (L)			Std. Meter Temp.	Meter Box Temperature					Time (Min.)			
ΔH	ΔP	Yds	Initial	Final	(Vds) Net	(L) Initial	(L) Final	(Vd) Net(ft³)	(T_{ds}) Avg.	(T_i) Inlet Init.	Inlet End	(T_o) Outlet Init.	Outlet End	(T_d) Avg.	Ø	(L/Min.) Q	Yd	ΔH@
0.0001	-0.06	1.000	72.320	72.640	0.320	613.200	622.400	0.325	62.0	66	69	63	66	66.0	25.8	0.357	0.9925	
0.0001	-0.06	1.000	72.640	72.960	0.320	622.400	631.600	0.325	62.0	70	70	66	66	68.0	25.8	0.357	0.9962	
0.002	-0.090	1.000	73.000	73.500	0.500	633.000	647.500	0.512	70.0	70	71	72	73	71.5	21.93	0.646	0.9791	
0.002	-0.090	1.000	73.500	74.000	0.500	647.500	662.000	0.512	70.0	71	74	78	72	72.0	21.93	0.646	0.9800	
0.004	-0.010	1.000	74.200	75.100	0.900	668.000	694.500	0.936	72.0	78	80	76	77	77.8	25.08	1.013	0.9722	
0.004	-0.010	1.000	75.100	76.000	0.900	694.500	721.100	0.939	72.0	80	81	77	78	79.0	25.10	1.012	0.9708	

Comments: This is the Calib. Cert. sheet.

Variables:

- Q = Flow rate (cfm)
- ΔH = Orifice pressure differential (in. H_2O)
- ΔP = Inlet pressure differential standard meter (in. H_2O)
- Yds = Standard meter correction factor (Unitless)
- Yd = Meter box correction factor (Unitless)
- $\Delta H@$ = Orifice pressure differential that gives 0.75 DSCFM of air at 68°F and 29.92 in. Hg (in. H_2O)

$$Yd = (Yds)\left(\frac{Vds}{Vd}\right)\left(\frac{Td+460}{Tds+460}\right)\left(\frac{Pb+\Delta P/13.6}{Pb+\Delta H/13.6}\right)$$

$$\Delta H@ = \frac{0.0317 \times \Delta H}{Pb(T_o+460)}\left[\frac{(Tds+460)\theta}{Vds \times Yds}\right]^2$$

$$Q = \frac{17.64 \times Vds \times Pb}{(Tds+460)\theta}$$

1 Yd Tolerance: $(Yd_{avg}-Yd) \pm 0.02$ ref. Fig 5 6 in EPA method 5

2 ΔHg Tolerance: $(\Delta Hg_{avg}-\Delta Hg) \pm 0.20$ ref. fig 5 6 in EPA method 5.

Excel FX XLS

101

Best Environmental, Inc. San Leandro, California (510)483-0515

Spring Type Thermometer Calibration

Calibrated By: Darren M. Lane

Date Calibrated: 10-7-96

Calibration Due: 6 months 4-7-97

LF2400
8383

Thermometer ID	Reference Thermometer Temp. (°F)	Test Thermocouple Temp (°F)	Temp. Difference	% Difference	Notes
22H #8383	112	111	-1		
22A IN"	78	78	0		
22A "	33	34	+1		
18A "	111	112	+1		
18A OUT	78	79	+1		
18A "	33	34	+1		
20A LF2400	102	100	-2		
20A IN	~~84~~ 76	75	-1		
20A "	41	40	-1		
20B "	104	100	-4		
20B OUT	84	83	-1		
20B "	41	40	-1		

NIST Pyrometer: T134449

ASTM Thermometer: 61132-006 76 mm

Comments: PASSED

Reference Thermometer: ASTM mercury in glass.
Method Reference: EPA QA Handbook Vol. III: Stationary Source Specific Methods, sect. 3.5.2.2
Tolerance Limits: ±5.4 °F at ambient temperature and in hot water bath.

000205

APPENDIX E
PROCESS DATA

Revised Toluene Addition to RTS #1 PCH 8/17/98

Ken measured RTS #1 today and found that only 22.66 kg RTS #1 in the container

1. Composition of ~~RT~~ undiluted RTS #1 excluding particulate

	wt. %	amount, g
MCM	92.68	20983
1,1-dichloroethene	1.51 %	342
Tetrachloroethane	3.02%	684
Trichloroethene	0.76%	172
Trichloro-trifluoroethane	2.11 %	478
	100 %	22660 g

Diluted with 12.34 kg Toluene

2. Composition of diluted RTS #1

	g	wt %	Feed rate g/min
MCM	20983	59.95%	24.98
1,1-dichloroethene	342	0.98%	0.41
Tetrachloroethene	684	1.95%	0.81
Trichloroethene	172	0.49%	0.20
Trichloro-trifluoroethane	478	1.37%	0.57
Toluene	12340	35.26%	14.69
	35000 g	100%	41.67 g/min

00210

Actual Feed Rate for RTS #1 Off-Gas Flow & Composition

PCH 8/24/98

(1) Average feed rate to the MSO vessel was 38.5 g/min ± 1.5 g/min (or 4.0 %)

For individual components,

Components	wt. %	rate, g/min
1,1,1 Trichloroethane MCM	59.95	23.08
1,1-dichloroethene	0.98	0.38
Tetrachloroethene	1.95	0.75
Trichloroethene	0.49	0.19
Trichloro-trifluoroethane (Freon)	1.37	0.53
Toluene	35.26	13.58
		38.5 g/min

(2) Off-gas Flowrate

per FI-01 (Flowmeter in the off-gas system), the off-gas flowrate was 15 ± 0.5 SCFM (which was consistent with the pitot tube measurements)

(3) CO_2 & O_2 in the off-gas:

about 10.0 % (as high as 12.0 %, as low as 8.0 %, average about 10.0 %)

000111

103

RTS #2 | Off-gas composition & PCH 8/24/98

Feed rates.

(1)

$CO_2 \approx 10.0\%$

$O_2 \approx 8.0\%$

Moisture 11.0%

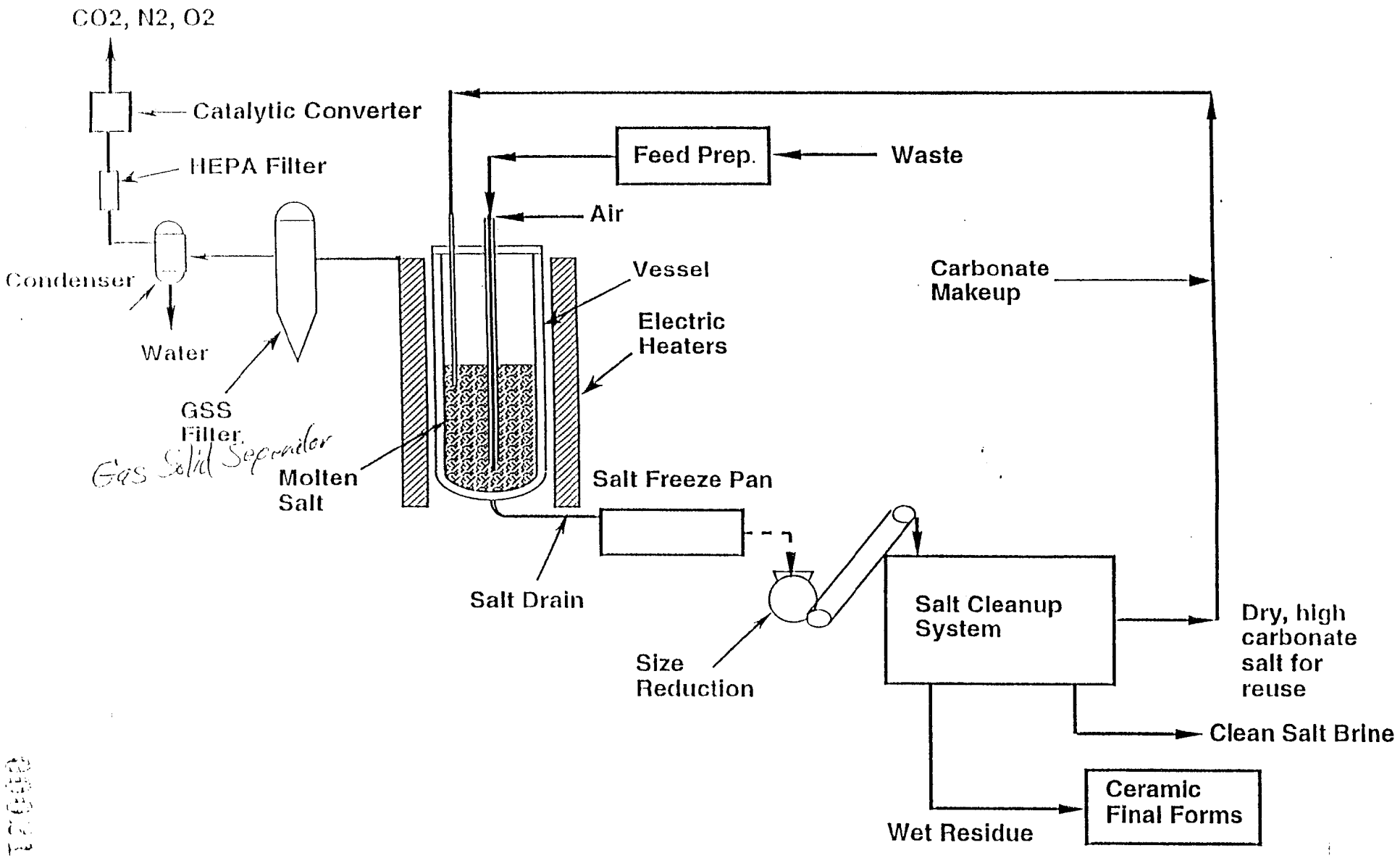
Gas flow will be ≈ 14.0 SCFM

(2) actual feed rate will be provided later

The preliminary information is:

Component	wt.%	rate, g/min
hydraulic oil	82.18	14.93
Toluene	15.29	2.78
Trichloro-trifluoroethane	1.19	0.213
1,1-Dichloroethene	0.14	0.025
MCM	0.93	0.168
PCB	0.13	0.0233
		18.1 g/min

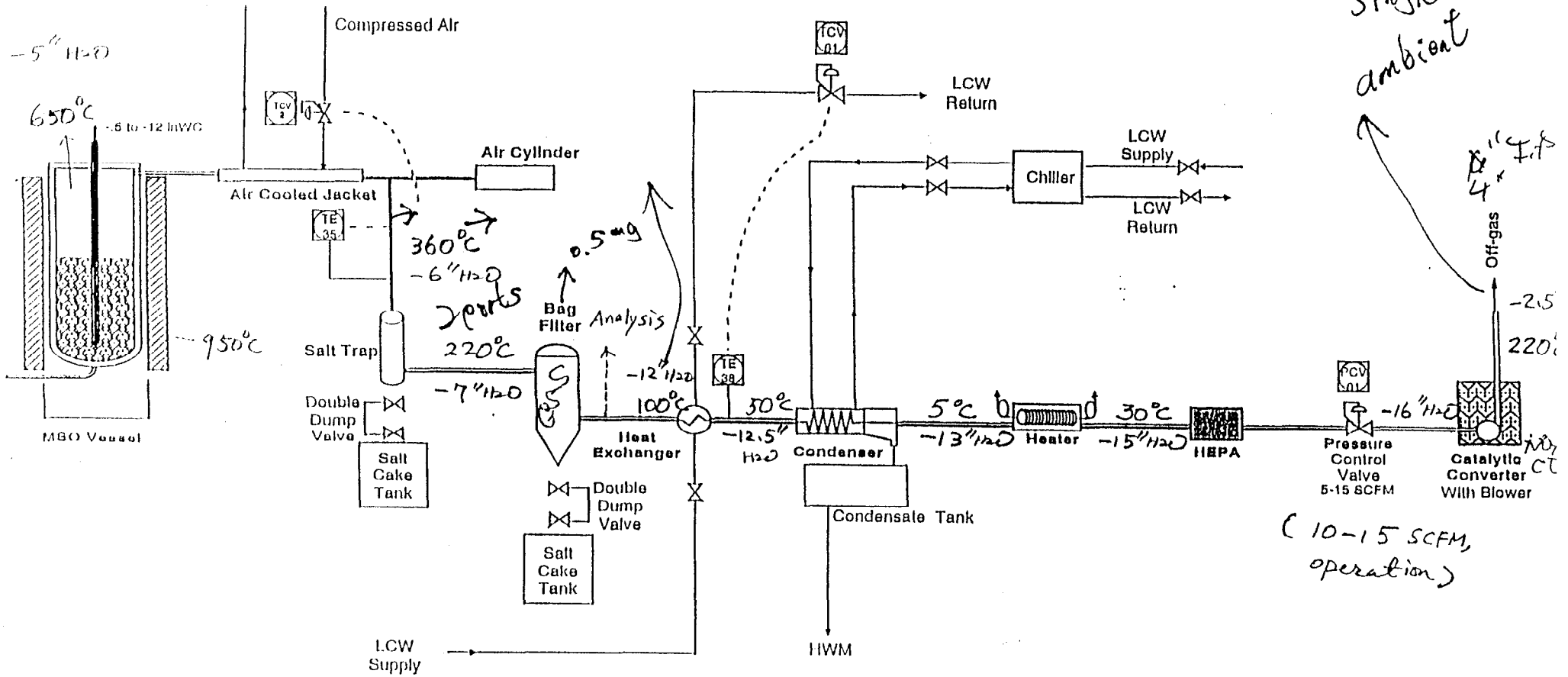
Integrated MSO System



3 locations

114
#23
0010
0030
single Run
ambient

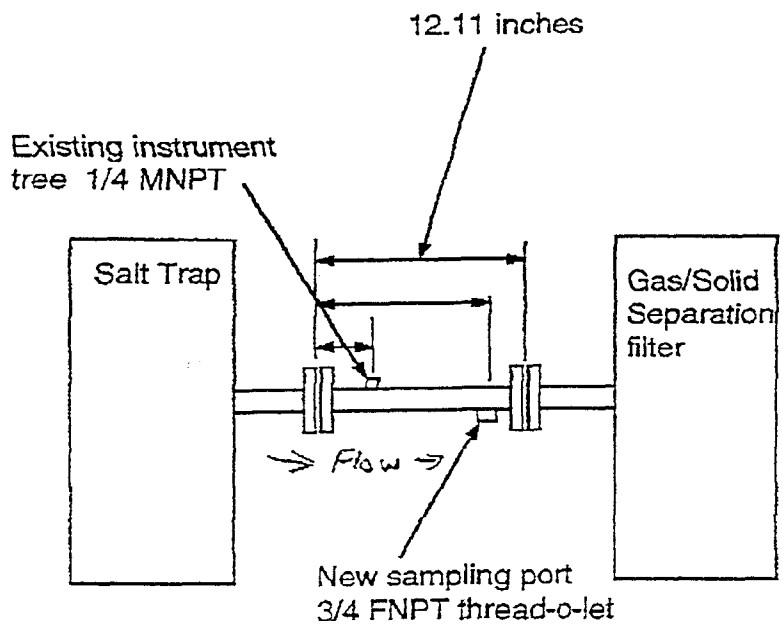
Fig. 3 Off-gas System



(10-15 SCFM, operation)

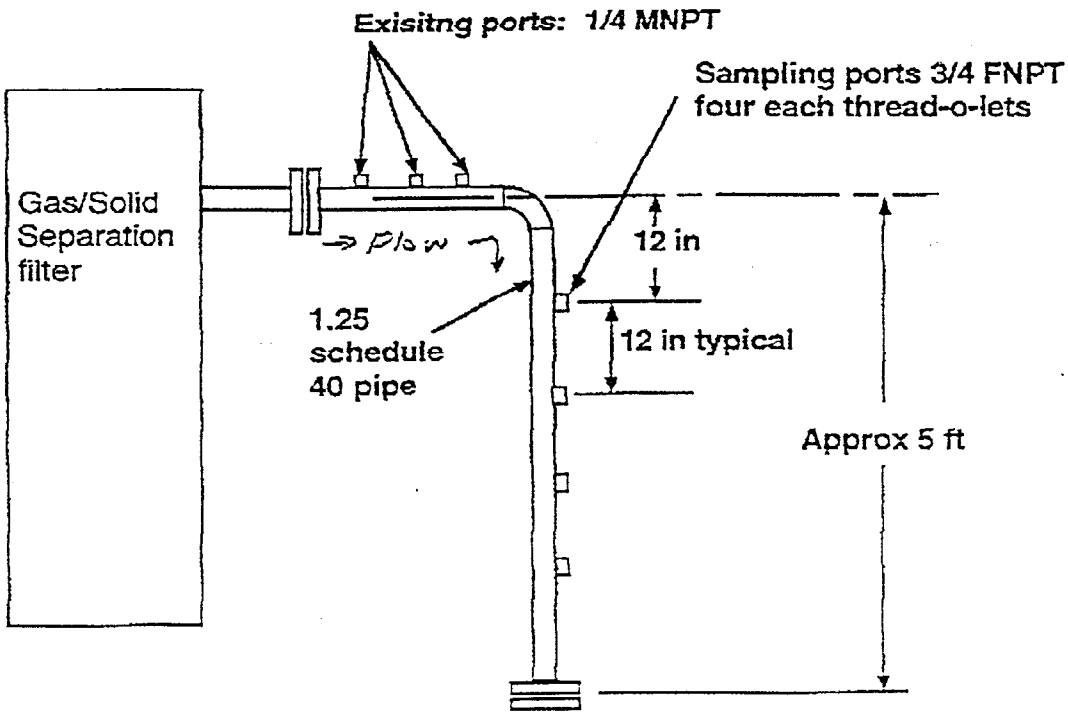
APPENDIX F
STACK DIAGRAMS

For the sample port between the Salt Trap and the GSS filter

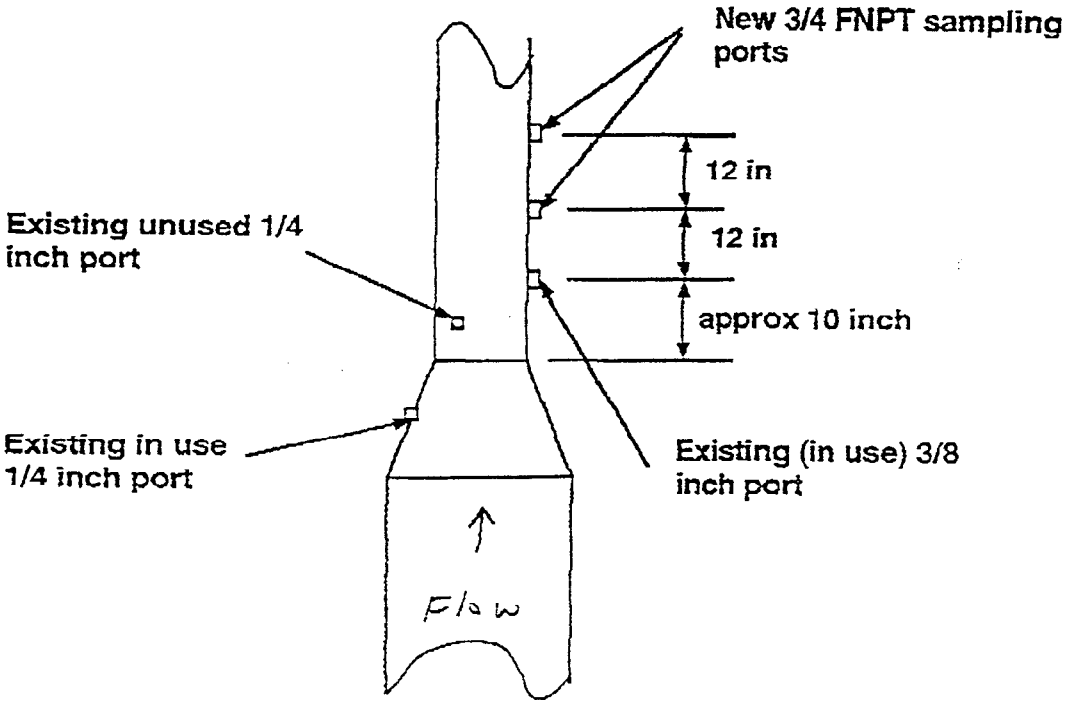


Existing bellows temporarily
replaced with rigid pipe.
1.25 pipe, Schedule 40

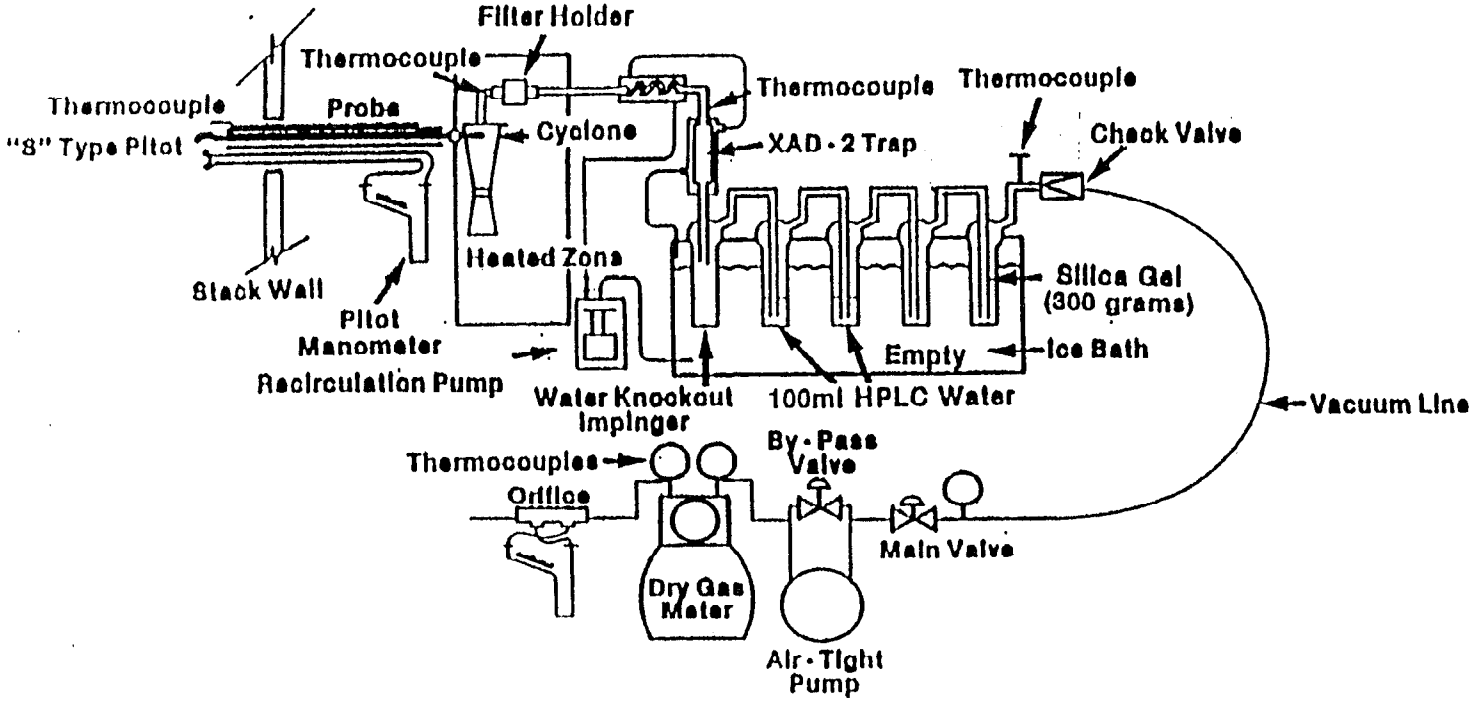
For the four sampling ports after the GSS filter



For the two sampling ports after the Catalytic converter

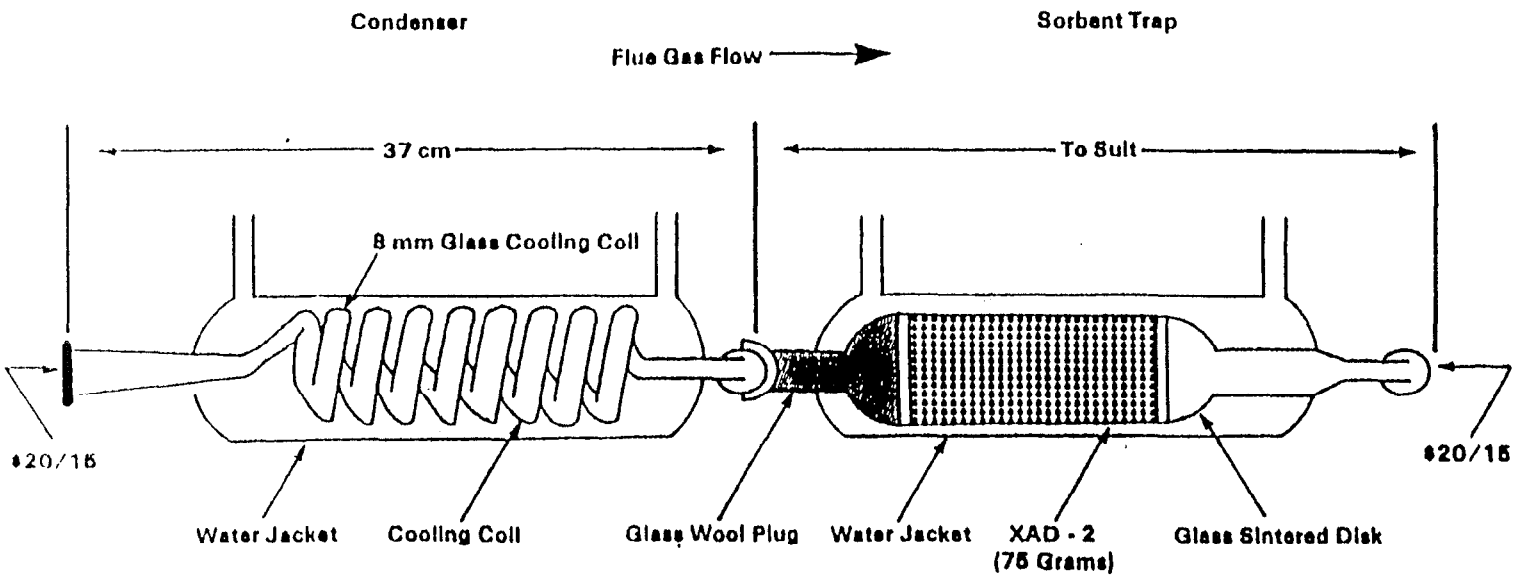


APPENDIX G
SAMPLING SYSTEM DIAGRAMS



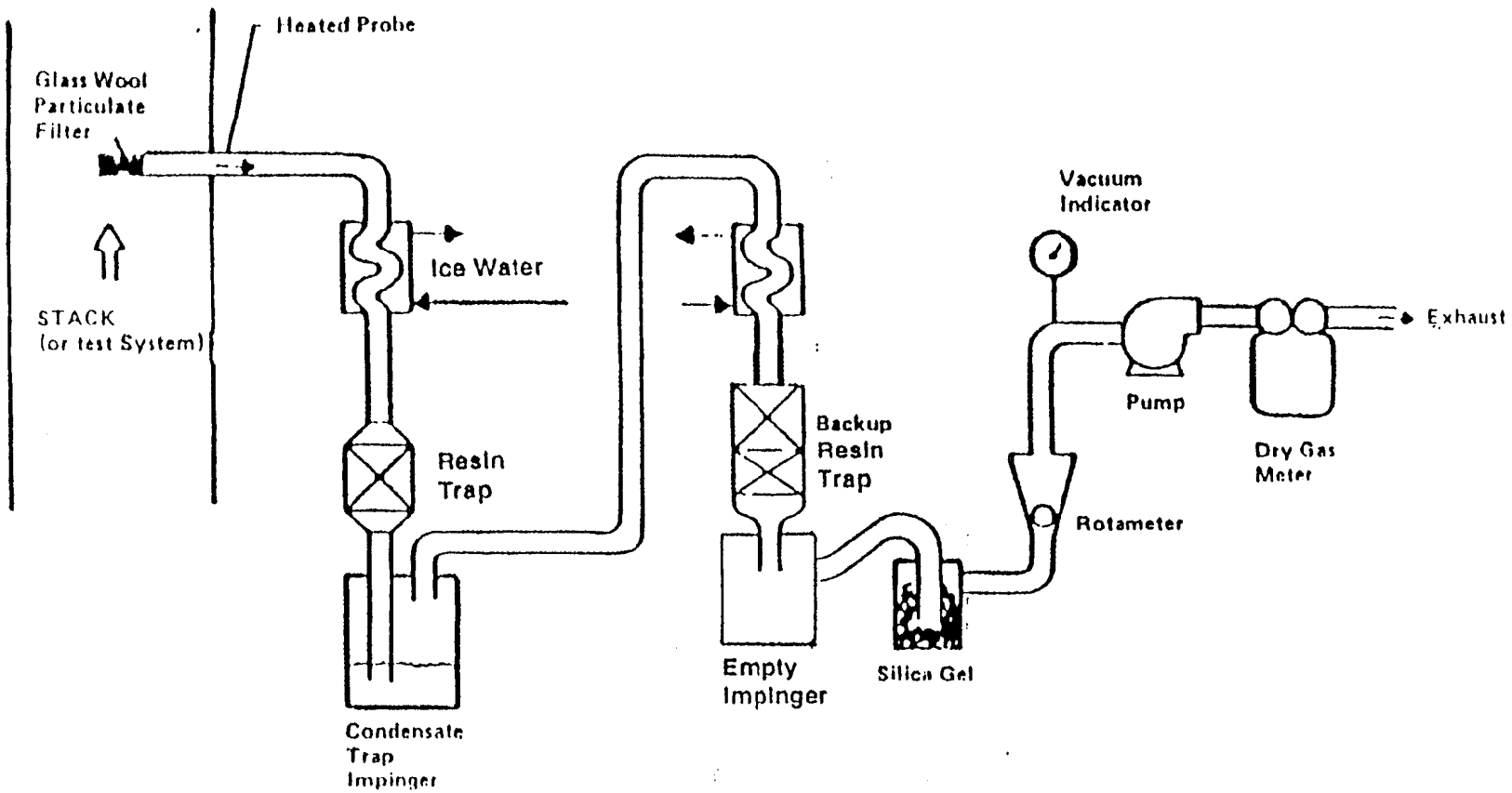
CDD/CDF Sampling Train Configuration

(Figure 1)

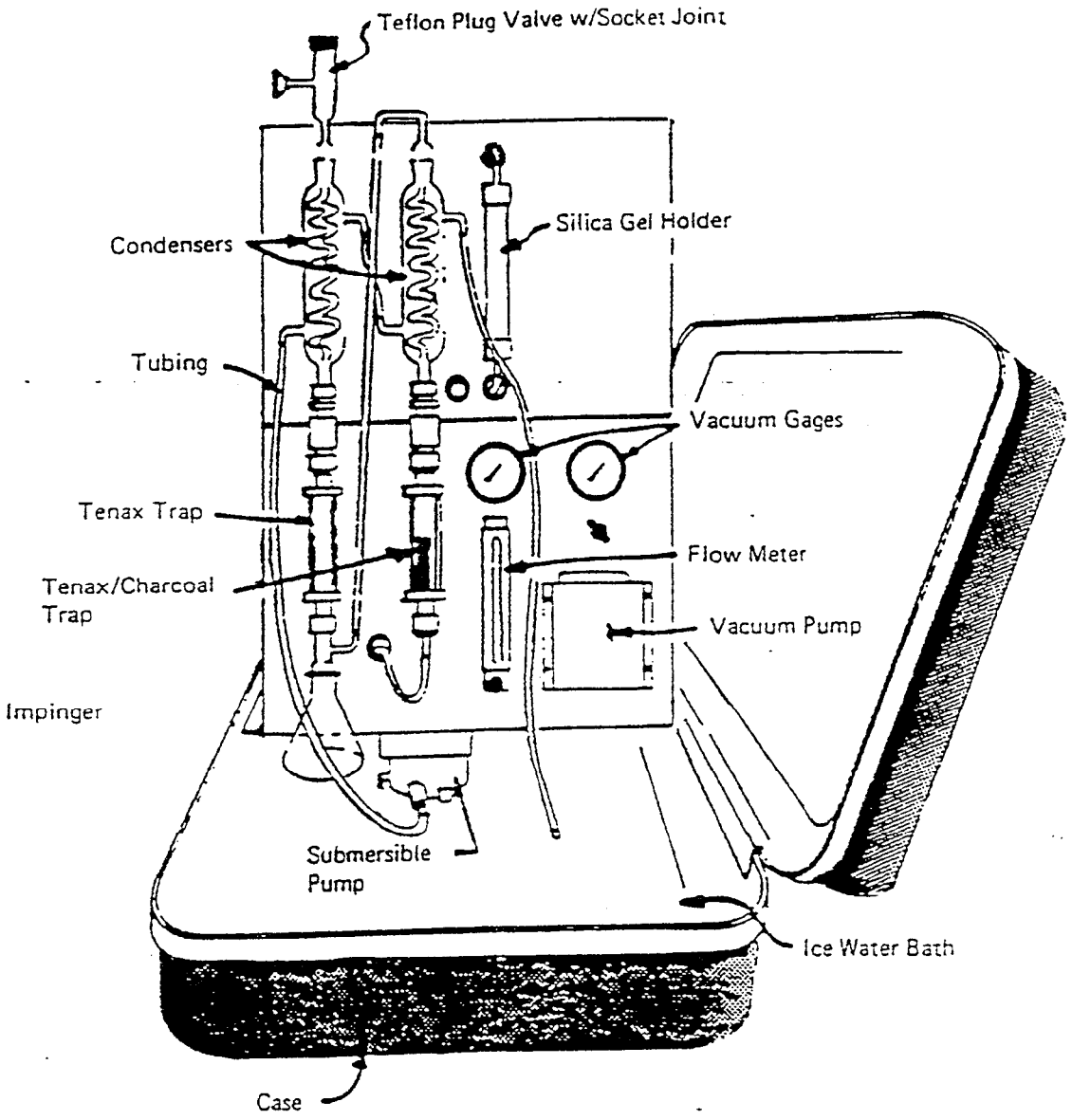


CONDENSER AND SORBENT TRAP FOR COLLECTION OF GASEOUS PCDDs AND PCDFs

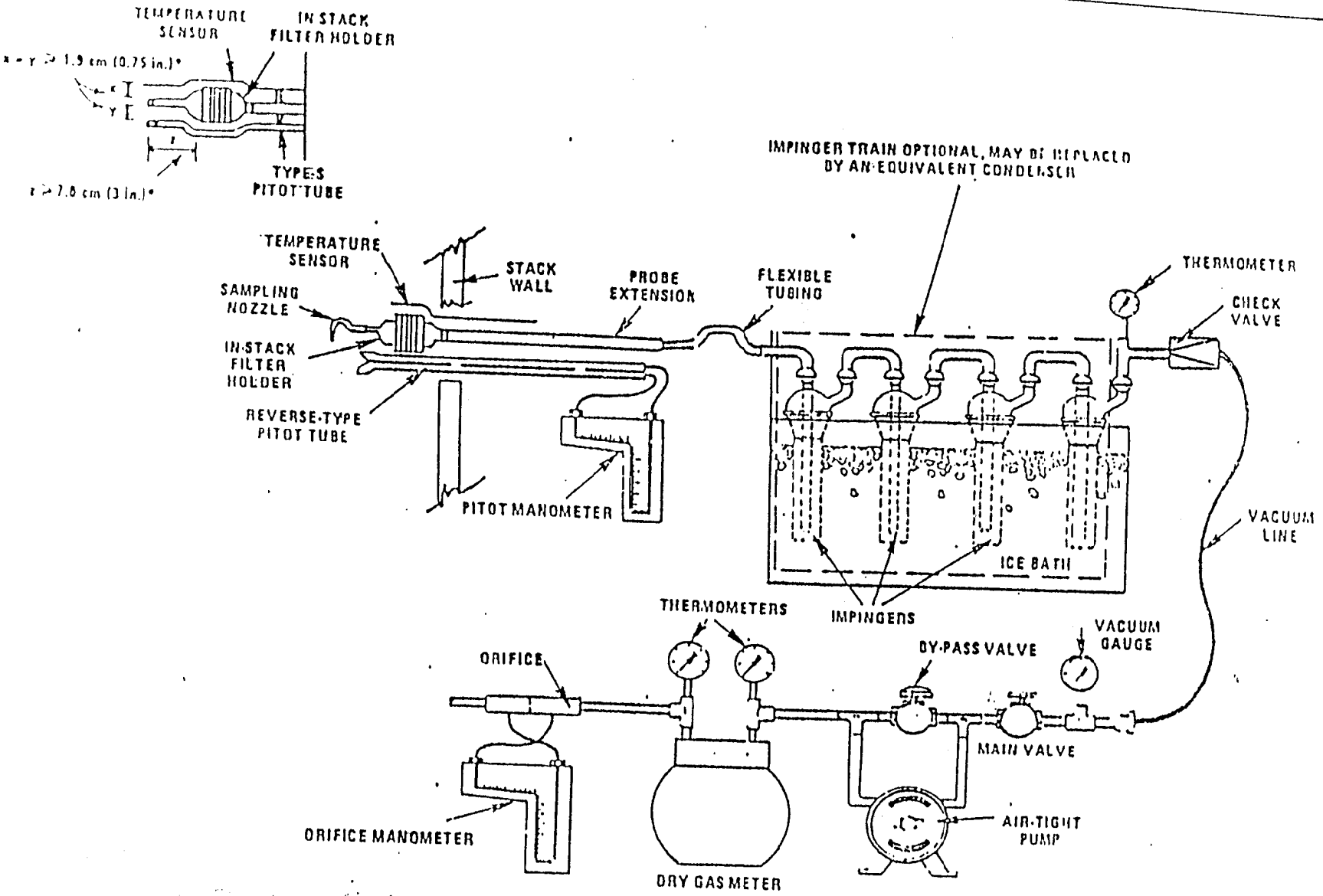
(Figure 2)



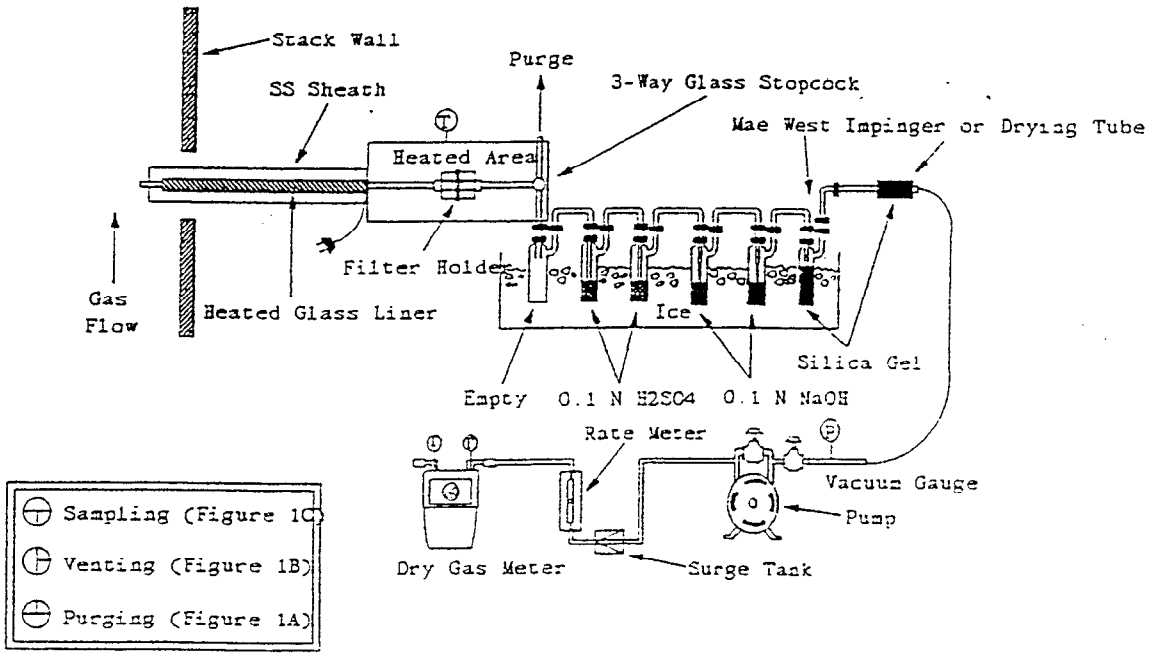
Schematic of Volatile Organic Sampling Train (VOST).



Volatile Organic Sampling Train (VOST).



Particulate-Sampling Train, Equipped with In-Stack Filter.



Method 26 & 0054

Sampling train.

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 21, 1998

LAB No: SP 807981-15

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: RIMS/114-IMP-CAT-OUT
Sampled by :
Type of Sample: Non Potable Water

Sampled : August 19, 1998
Received : September 25, 1998
Completed : October 20, 1998
QA/QC ID# : 80798115- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/L	1	± 1
Gross Beta	9310	pCi/L	1	± 2
Tritium	906.0	pCi/L	900	±300

Results x0.2?8
0.22
0.22
196.2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Glass

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172

Office & Laboratory
2600 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423

Field Office
Visalia, CA
TEL: 209/734-4473
FAX: 209/734-8436
Mobile: 209/787-0999

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 22, 1998

LAB No: SP 807981-13

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: RIMS/114-F/H-CAT-OUT
Sampled by :
Type of Sample: Solid

Sampled : August 19, 1998
Received : September 25, 1998
Completed : October 13, 1998
QA/QC ID# : 80798113- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/samp	0.0	± 1
Gross Beta	9310	pCi/samp	0.0	± 1
Tritium	H-1	pCi/samp	0.0	± 2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Plastic

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

000121

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-8435
Mobile: 209/737-4999

FGL ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 22, 1998

LAB No: SP 807981-14

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: R1MS/114-Filter-CAT-OUT
Sampled by :
Type of Sample: Air Filter

Sampled : August 19, 1998
Received : September 25, 1998
Completed : October 19, 1998
QA/QC ID# : 80798114- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/samp	0.33	± 0.45
Gross Beta	9310	pCi/samp	0.44	± 1.2
Tritium	H-1	pCi/samp	0.2	± 2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Glass

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805.525-0910
FAX: 805.525-4172

Office & Laboratory
3330 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0182
FAX: 209/942-0423

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-8435
Mobile: 209/737-2399

FGL ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 22, 1998

LAB No: SP 807981-4

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: R4MS/114-F/H-B-OUT-BLK
Sampled by :
Type of Sample: Solid

Sampled : August 18, 1998
Received : September 25, 1998
Completed : October 13, 1998
QA/QC ID# : 80798104- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/samp	0.0	± 1
Gross Beta	9310	pCi/samp	0.0	± 1
Tritium	H-1	pCi/samp	0.0	± 2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Plastic

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

000123

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172
CA ELAP Certification No: 1573

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423
CA ELAP Certification No: 1561

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-8435
Mobile: 209/737-2399

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 22, 1998

LAB No: SP 807981-8

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: R4MS/114-FILTER-B-OUT-BLK
Sampled by :
Type of Sample: Air Filter

Sampled : August 18, 1998
Received : September 25, 1998
Completed : October 19, 1998
QA/QC ID# : 80798108- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/samp	0.00	± 0.43
Gross Beta	9310	pCi/samp	0.0	± 1.3
Tritium	H-1	pCi/samp	1.2	± 2

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Glass

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-8435

113

ENVIRONMENTAL

ANALYTICAL CHEMISTS

October 21, 1998

LAB No: SP 807981-12

Best Environmental, Inc.
15890 Foothill Blvd,
San Leandro, CA 94578

RE: Radiological Analysis

Sample Site: LLNL
Description: R4MS/114-IMP-B-OUT
Sampled by :
Type of Sample: Non Potable Water

Sampled : August 18, 1998
Received : September 25, 1998
Completed : October 20, 1998
QA/QC ID# : 80798112- A

Analytical Results

CONSTITUENT	EPA METHOD	UNITS	RESULTS	ERROR
Gross Alpha	9310	pCi/L	0.0	± 1
Gross Beta	9310	pCi/L	0.0	± 3
Tritium	906.0	pCi/L	600	±300

pCi/L = pico Curies per Liter pCi/ml = pico Curies per milliliter
Containers: (a) Glass

× 0.2 liter = 120 pCi

If you have any questions, please call.

FGL ENVIRONMENTAL

Michel M. Franco, B.A.
Radiochemistry Lab Manager

MMF:vt

000125

This report package is not intended for use in the State of Utah unless bound or paginated

Corporate Offices & Laboratory
PO Box 272 / 853 Corporation Street
Santa Paula, CA 93061-0272
TEL: 805/659-0910
FAX: 805/525-4172
CA ELAP Certification No: 1573

Office & Laboratory
2500 Stagecoach Road
Stockton, CA 95215
TEL: 209/942-0181
FAX: 209/942-0423
CA ELAP Certification No: 1563

Field Office
Visalia, CA
TEL: 209/734-9473
FAX: 209/734-8435
Mobile: 209/737-2399

BEST ENVIRONMENTAL, INC. San Leandro, CA 94578 (510) 278-4011

Analytical report

Job Name: LLNL
Sample Date: 8/26/98
Request by: R. Best
Analytical Method: Method 5 EPA
Date of Anaysis: 8/31/98 to 9/17/98
Source: GSS outlet

Analyst: Michael J. Wiley
Signature:

Lab ID Number	Sample (ml)	Aliquot (ml)	Parameter	Net Weight gain, (mg)	Result Blank Corrected
R1M5 (Probe/Nozzle rinse)	50.0ml	50.0ml	Particulate	0.44mg	**0.71mg**
R1M5 (Filter)	N/A	N/A	Particulate	0.11mg	**0.11mg**
R2M5 (Probe/Nozzle rinse)	50.0ml	50.0ml	Particulate	0.25mg	**0.52mg**
R2M5 (Filter)	N/A	N/A	Particulate	-0.08mg	**<0.05mg**
R3M5 (Probe/Nozzle rinse)	50.0ml	50.0ml	Particulate	0.21mg	**0.48mg**
R3M5 (Filter)	N/A	N/A	Particulate	-0.04mg	**<0.05mg**
R4M5 (Acetone blank)	50.0ml	50.0ml	Particulate	-0.27mg	
R4M5 (Filter blank)	N/A	N/A	Particulate	0.00mg	

Comments: < 0.05 mg = Not detected

% Acetone Residue = -0.0007%

Calculations:

Probe/Nozzle rinse = Net weight - ((acetone blank wt./vol. acetone blank)*vol. acetone catch)

% Acetone residue = (New weight gain * 0.1) - (density of acetone * total sample volume)

Tolerance Limits: % Acetone residue = 0.001% wt.

Particulate weight = 1% of net wt., ±0.5 mg or ±0.05 mg depending upon precision

Analytical report

Job Name: LLNL
Sample Date: 8/26/98
Request by: R. Best
Analytical Method: Method 5 EPA
Date of Anaysis: 8/31/98 to 9/17/98
Source: Catalyst outlet

Analyst: Michael J. Wiley
Signature:

Lab ID Number	Sample (ml)	Aliquot (ml)	Parameter	Net Weight gain, (mg)	Result Blank Corrected
R1M5 (Probe/Nozzle rinse)	32.0ml	32.0ml	Particulate	-0.11mg	**0.06mg**
R1M5 (Filter)	N/A	N/A	Particulate	0.10mg	**0.10mg**
R4M5 (Acetone blank)	50.0ml	50.0ml	Particulate	-0.27mg	
R4M5 (Filter blank)	N/A	N/A	Particulate	0.00mg	

Comments: < 0.05 mg = Not detected

% Acetone Residue = -0.0007%

Calculations:

Probe/Nozzle rinse = Net weight - ((acetone blank wt. vol. actone blank)*vol. acetone catch)

% Acetone residue = (New weight gain * 0.1) / (density of acetone * total sample volume)

Tolerance Limits: % Acetone residue = 0.001% wt.

Particulate weight = 1% of net wt., ±0.5 mg or ±0.05 mg depending upon precision

000127